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October, 1956

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OCTOBER 1956 **VOL. 44, NO. 4**

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Materials Outlook

FIBERGLASS PANELS REINFORCED WITH METAL are being offered. The inner web of metal is claimed to: 1) add greatly to the strength of the panel, 2) provide a variety of decorative effects, obtained by varying the metal and plastics patterns, and 3) allow panels to be secured in place by welding special attachments to the metal web.

COLUMBIUM AND TANTALUM can now be extracted and separated by less costly methods than presently used. The new technique, which uses solvent extraction, will probably make economical the utilization of low-grade ores.

A NUT THAT TIGHTENS instead of loosening under vibration is being made in England. Consisting of a stack of resilient metal disks assembled in a hollow body, the nut is designed to exert increasingly greater pressures against the bolt threads as it is tightened. Vibration merely increases this pressure. Good fatigue life is claimed as a result of favorable load distribution between the engaged threads.

IMPROVED SILICON CARBIDE has resulted from a new method of self-bonding. The new material has higher flexural strength, higher stiffness, lower permeability, better thermal properties and higher abrasion resistance than conventional silicon carbide. It can be fabricated by the usual methods. (See article on p 92 for more details.)

A STABLE COPPER PRICE in the coming months forecast by one industrial research organization. This organization says that copper supply is adequate and price movements will be narrow. It advises strongly against accumulating more than normal inventories. In contrast, demand for aluminum coupled with the marginal supply picture is expected to produce a continuation of the gradual rise in price for aluminum.

UNBREAKABLE GLASS with good machinability may result from new compositions now being studied. This type of glass might replace metals in a variety of applications.

COLUMBIUM (niobium is being investigated for possible application in jet aircraft turbines. Advantages of columbium include: 1) higher melting point than present metals, 2) density equal to that of steel, and 3) strength, when combined with certain alloys, that promises to be twice that of current high temperature alloys.

CHLORINATED POLYETHER, a new thermoplastic, has withstood more than a year's service in a 61 psig steam valve. The new resin, which can take sterilization temperatures and has very low water absorp-

Materials Outlook

tion, should be useful where temperature, chemical resistance and dimensional stability requirements are too stringent for conventional thermoplastics. Under development for more than a year, the material is now in pilot plant production and is undergoing service testing. (See article next month for more details.)

LATEST MATERIAL PRICE CHANGES: Magnesium — Pig and ingot primary prices have been raised 1½¢ per lb by Dow Chemical, the increase for magnesium wrought products averaging 5%. Molding resins — M. W. Kellogg lowered prices of fluorocarbon molding resins as much as \$2.50 per lb. Prices per pound for standard low density grades now range from \$6.00 to \$7.00 in large quantities. Urethane coatings — Price reductions up to 36% on basic chemicals used in the manufacture of urethane surface coatings were announced by Mobay Chemical. Stainless steel — Recent increases in the average base price of stinless steel mill products range from 2¢ per lb on cheaper products to 5¢ per lb on some of the more expensive products.

PEWTER can be restored to as-cast hardness after working. Researchers have found that pewter containing a small amount of silver regains its original hardness when heat treated at low temperatures.

DUCTILE CERAMICS may result from basic research under way. The basic work is being done with ionic solids — salts that, like ceramics, are hard and brittle. Researchers have found that these materials exhibit ductility when subjected to the proper environment. It is hoped that more study may establish the basic principles governing the ductility of ceramics and other materials.

ANALYSIS OF MATERIALS may be simplified by use of beta rays. The amount of backscattering of beta particles (those particles that rebound toward the source of emission) can be correlated directly with the composition of any material. Big advantage of the method, still under study, is the inexpensive equipment needed and the simple and rapid nature of the measurement.

FLUOROCARBON ELASTOMER-COATED NYLON is being produced on a sample-lot basis. Glass and Dacron fabrics coated with this Kel-F elastomer are under development. Significant properties include high resistance to swelling and deterioration when in contact with JP-4 and JP-5 fuels as well as corrosive chemicals.

ALL-BUTYL CAR TIRES may be here in the near future. Process refinements will allow commercial production with standard equipment. Advantages of butyl rubber over GR-S (used in present passenger car tires) are: 1) less tire "cracking" by aging, 2) better shock absorption, 3) less tire squeal and 4) improved frictional characteristics.

Materials BRIEFS

Icy Impact Test
Aircraft fuselage sections are tested by driving 40-lb blocks of ice against them. Test simulates the landing of a plane in the Arctic where ice mounds on runways are common.

Light Magnet
An electromagnet has been made from a thin sheet of aluminum foil. The new magnet is said to be cheaper and lighter than similar types and can operate at higher average temperatures.

Transparent Fact
Per capita use of plate and window glass has increased by more than 200% in the last 30 yr. Window glass is being consumed at the rate of 10 sq ft per person and plate at about 3½ sq ft.

Frosty Props
Twenty-two of the ships that recently took part in exercises above the Arctic Circle were equipped with propellers of a nickel-aluminum-bronze alloy. The low temperatures had no deleterious effect on the new alloy.

Hot Dogs
Two cone-shaped pieces of asbestos laminated with aluminum foil make up a portable barbecue. Unit will cook eight to ten frankfurters or six to eight hamburgers in record time.

Dealer's Dream
Car colors of the future will be changed at will to suit the shade of the wife's new outfit. So says one researcher who envisages the use of a neutral white paint containing a photosensitive pigment that could be colored by using an electromagnetic radiation gun.

Neat Meat
A nonstick enamel lining for containers permits meat products to slip out easily. Enamel is now being furnished on ham and luncheon meat cans.

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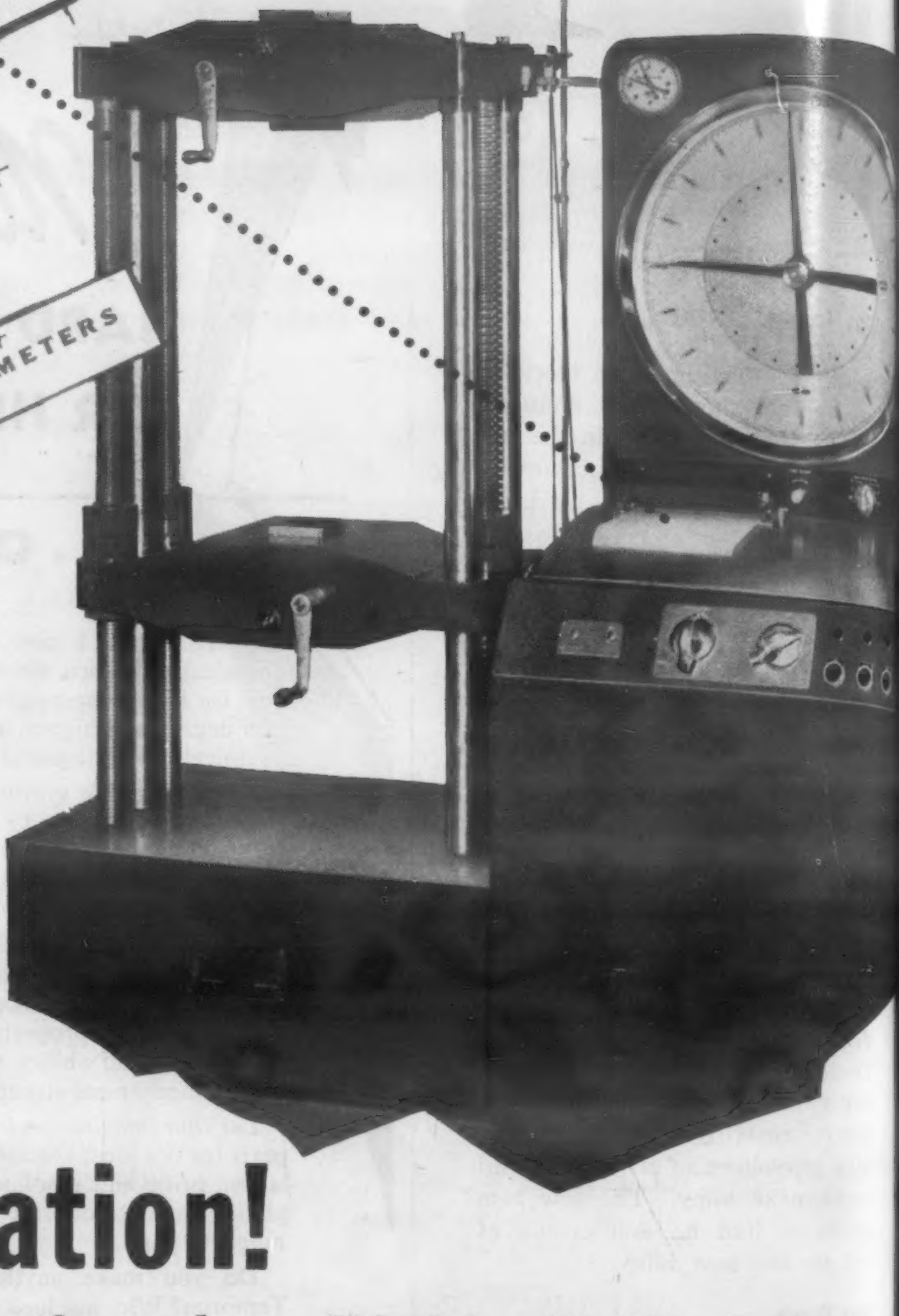

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ATTENTION MR

Men of Materials...

Promisel says:

"We must develop new composite materials, and we must learn to live with them."

N. E. Promisel,
Head, Materials Branch, Navy Bureau of Aeronautics, began his career as a research electrochemist with International Silver in 1930 and held the title of Assistant Director of Research when he resigned in 1940 to do private consulting work. When war came, Mr. Promisel joined the Bureau and assumed his present position in 1948. He holds a B. S. and M. S. in Electrochemical Engineering from M.I.T.

"IT IS evident to those working on new materials development that current demands of mechanical strength, deteriorating environment, and particularly high temperature are pushing conventional materials to the limit. The chances of revolutionary advances with these materials are slight. One major potential, both for national defense and for national economy, lies in the development of composite materials in which each component contributes a necessary function so that only the composite fulfills all requirements.

"We must plow new fields—go from organic polymers to inorganic polymers or to organo-inorganic-metallic complexes; from materials melting below 2500 F to those that will not melt one, two, or three thousand degrees higher; from metals to ceramics and cermets. We must advance from liquid lubricants to gaseous, from atmospheric processing to inert gas or vacuum operation.

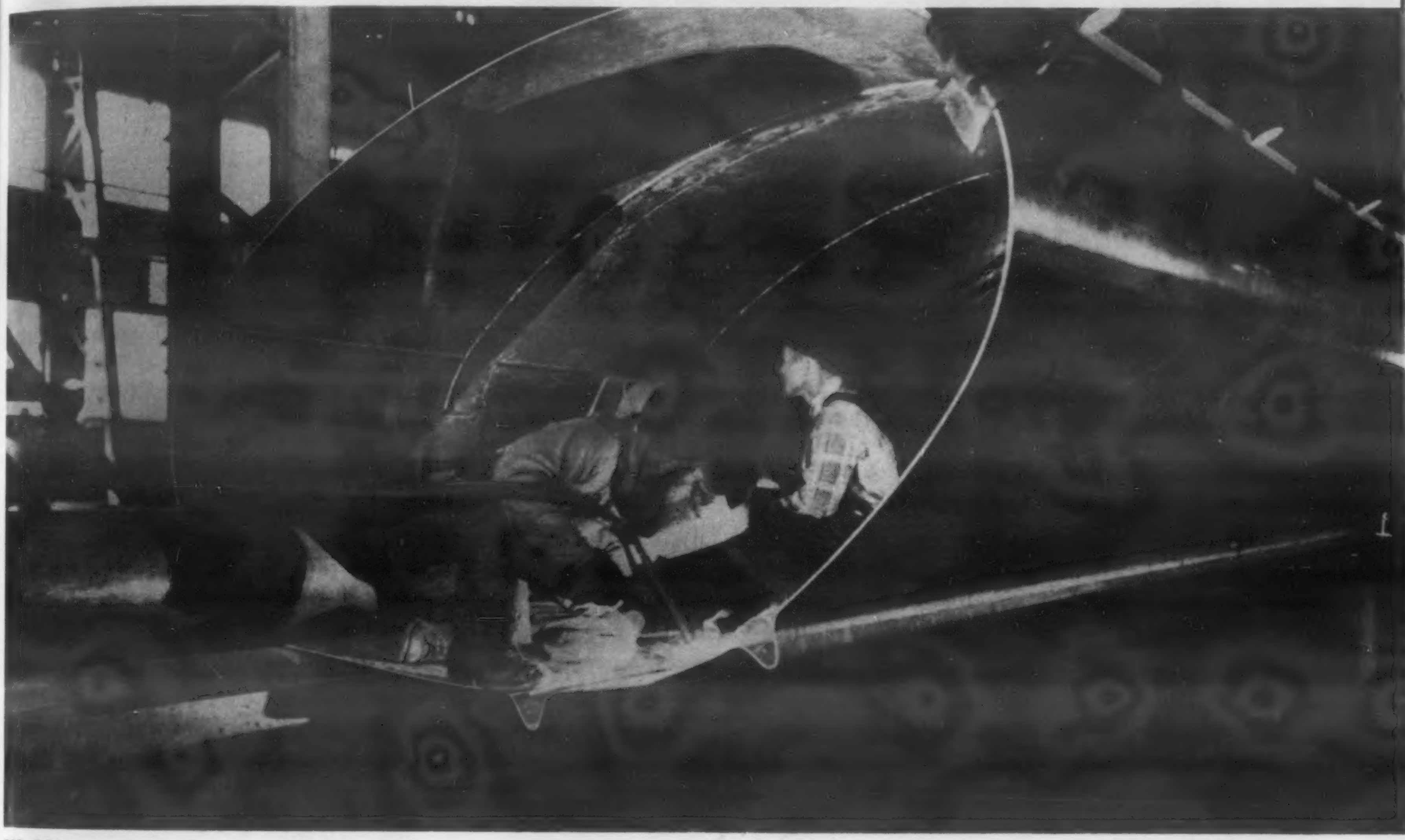
"We need to develop new theories of synthesizing materials for specific applications—composite metal laminates; marriages between resins and synthetic nonmetallic and metallic reinforcing fibers, shapes and dispersoids; new concepts of curing, heat treating and hardening.

"Then we must learn to live with the new materials. Materials engineers and designers of equipment must cooperate more than ever and must do so *before* design is completed and not so late that the overnight creation of new and exotic materials is required. We must realize now that it is tilting at windmills to insist on all the *new* requirements for materials *plus* all the old attributes. Creating a brave, new world of materials requires a blend of boldness and innovation in design, together with ingenuity in synthesizing the new materials."

MATERIALS ENGINEERING NEWS

This month

- *New aluminum alloy*
- *Ultra-pure silicon*
- *New nickel source*



***Welding** an aluminum pressure vessel.* Kaiser Aluminum

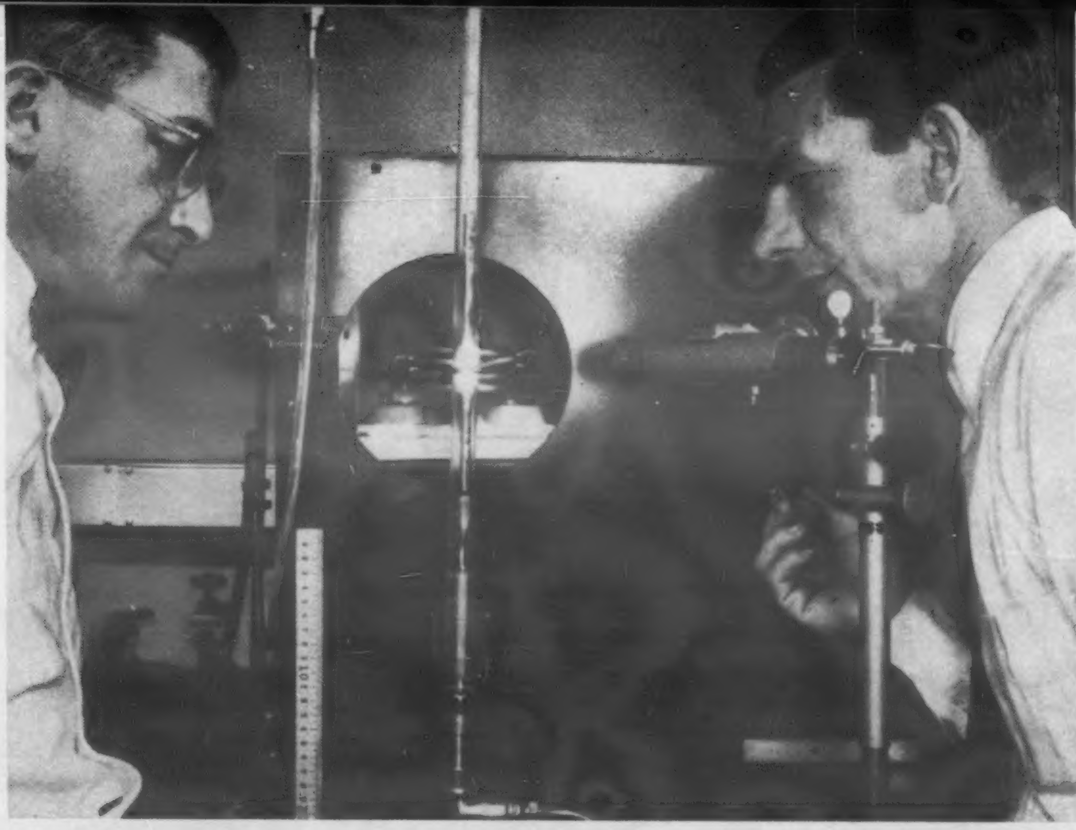
ASME Boiler Code Committee accepts . . .

Stronger Aluminum Alloy for Pressure Vessels

■ The recent announcement that permission to use aluminum alloy 5086 for the fabrication of unfired pressure vessels has been granted by the ASME Boiler and Pressure Vessel Code Committee is another step that should expand the use of aluminum in such applications.

Until 1952, 1100 and 3003 (then 2S and 3S) were the only aluminum alloys listed by the Code. The 1952 Code listed a total of seven, with approval of 5052 (52S) representing an increase of 87% in allowable design stress over that of 3003 for welded construction. In 1954, permission to use 5154 (designated GR40A by ASTM) raised this allowable stress to 7350 psi, an increase of 18% over 5052. Now alloy 5086 (GM40A) with an allowable stress of 8700 psi for welded vessels up to 150 F, pushes permissible design stresses up another 18%.

The new alloy was developed by Kaiser Aluminum to provide maximum joint strength, taking advantage of inert-gas-shielded arc welding methods. Applications have included structural towers, cranes, tanks and boat hulls.



Boron-free silicon *results when molten silicon is reacted with water vapor. A liquid silicon zone supported only by surface tension traverses a vertical silicon rod around which flows a mixture of hydrogen and water vapor.*

Method for Removing Boron Produces Ultra-Pure Silicon

■ Ultra refining techniques continue to improve the usefulness of various materials. Latest advance is the removal of boron from silicon used for semiconductor devices.

H. C. Theuerer, of Bell Telephone Laboratories, found that this nuisance material could be removed from molten silicon through a reaction with water vapor. The reaction oxidizes the boron and the oxidation products evaporate.

Used together with the zone refining technique, this method makes possible the production of silicon containing boron in a concentration below one part in ten billion. The purified silicon has a resistivity greater than 3000 ohm-cm. Improved transistors and other semiconductor devices may result from this material.

Magnesium Chosen for Earth Satellite

■ Twin hemispheres of magnesium will be joined to form the near perfect sphere needed for the proposed earth satellite. Although magnesium would seem to be an obvious choice because of its light weight, it was first believed that the heat generated from air friction would be too high for it. However, as the velocity is increased by each stage of the three-stage rocket, the atmosphere will be thinner in such proportion as to keep the friction temperature within reasonable limits.

The ball will be 20 in. in diameter, a perfect sphere on the inside with slight variations in wall thickness to give the outside shape which was determined to be necessary. The wall thickness will be about 0.02 in. Each half of the sphere will be drawn from a single sheet of magnesium alloy. The outside skin will be extremely smooth and polished mirror-bright.

It is anticipated that the satellite will be completely destroyed by air friction heat when it falls. The choice of a magnesium alloy for the satellite body was announced by Brooks and Perkins, Inc., the company assigned by the Office of Naval Research to manufacture the spheres.

Isotope radiography machine *made by Budd Co. is completely self-contained, requires no power supply and can be wheeled about by one man.*

Radioisotope Use Mounts

■ Radioactive materials are finding increasing use in industrial and research applications, according to a survey by the Atomic Industrial Forum. The number of industrial users of radioactive isotopes has increased more than 500% within the past five years.

More than 1000 industrial organizations are using atomic energy by-product materials in 1347 different installations. Some 350 firms are using nuclear by-product materials in radiation inspection of welds and castings and in other metalworking operations. More than 400 organizations in paper, steel, textiles, rubber, plastics and glass are utilizing radioactive isotopes for gaging and control operations.

According to estimates released by the Atomic Energy Commission, radioisotope applications now result in annual savings to industry of $200 million per year. AEC

Molten nickel *fills pouring ladle from electric furnaces at National Lead's new nickel refinery.*

Nickel ingot *molds are poured on revolving casting machine in second phase of operation.*

New Nickel Refinery Adds to Vital Supply

■ The Crum Lynne, Pa., nickel refinery of the National Lead Co. recently shipped the first lot of an expected 14 million pounds of metallic nickel per year. In accordance with government stockpile regulations the nickel was sold at the prevailing market price to various steel companies.

The shipments mark the first time a domestic source of nickel other than International Nickel Co. has been available. The Crum Lynne plant began production in June and output has been increasing steadily with full production expected by the fourth quarter. In 1955 approximately 219 million pounds of metallic nickel in pig form was purchased in the U.S. Based on this figure the new source should increase the available supply by more than 6.5%.

The National Lead plant was originally a steel mill which has been converted to handle the nickel oxide obtained from a U.S.-owned facility at Nicaro, Cuba. This Cuban plant, operated by the National Processing Corp., subsidiary of National Lead, is presently producing 31 million pounds a year of nickel oxide powder and sinter. Expansion plans nearing completion will add 75% to the present capacity.

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also estimates that this figure will reach the one billion dollar per year mark within the next ten years.

The most powerful isotope radiography machine yet developed was recently delivered to the Newport News Shipbuilding and Drydock Co. by the Nuclear Systems Div. of Budd Co.

Employing the radiation from a 50-curie cobalt-60 source, the machine is said to accomplish the same job as a 2,000,000-v x-ray machine, although it costs but a fraction of the price and requires no special installation. Remote control operation allows the source to be exposed at distances up to 50 ft from the operator with complete safety.

The 50-curie machine will be used to detect flaws in castings and in welded joints on such fabricated products as boilers, pressure vessels and pipelines.

At the right is a list of the industries and number of companies in each industry that have been using radioisotopes during the period 1946-1956.

(more News on p 246)

Abrasives, Coatings	5
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Textiles, Leather	18
Engineering, Construction	19
Aircraft	20
Building Materials	25
Piping, Valves, Tanks	30
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Machinery	55
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Electrical Equipment	110
Research, Development, Testing	120
Manufacturing (petroleum, chemicals, etc.)	363

LETTERS TO THE EDITOR

Fluorocarbon–glass laminate

To the Editor:

We noted in the Feb '56 issue of MATERIALS & METHODS, p 3, a news item concerning a new plastic laminate of fluorocarbon plastic on glass cloth. We would appreciate if possible if you could direct us to the supplier or applicator of this material.

DON SHOCKLEY, Chief Engineer
J. B. Seage, Inc.
South Gate, Calif.

The item referred to M. W. Kellogg Co.'s work with Kel-F monochlorotrifluoroethylene resin. Contact that company for further information.

Immersion trouble

To the Editor:

In an article entitled "Finishes For Metal Products," published in the September 1955 issue of MATERIALS & METHODS, there is set forth on page 127 a short discussion on immersion coatings.

The article mentions that tin coatings of about 0.02 to 0.05 mil provide a bright, decorative finish for brass, iron and steel parts. Further on, "thicker immersion coatings are used to lubricate steel wire in drawing and aluminum pistons during the running-in period."

We are extremely curious to obtain information on any immersion process, including tin, which provides more than 0.05 mil of finished thickness of the deposited metal. It is our understanding that without exception all immersion platers never exceed the 0.05 mil limitation of thickness. Apparently this is not true, at least for tin . . . We would be most appreciative if you would supply us with the necessary bibliography to pursue further the subject of immersion coats of tin plates that are thicker than 0.05 mil.

Indeed, we would be most interested in obtaining information on tin coatings that are "bright, decorative finishes for brass, iron and steel parts." We have yet to see such a coating provided for in any of the published solutions found in the usual literature or as supplied by the normal proprietary formulations.

RONALD B. HOWES, President
St. Eloi Corp.
Newtown, Ohio

An exchange of letters with Mr. Howes made it clear that the source of confusion was our use of the phrase "immersion coatings" to include all coatings deposited from ionic solution without the use of an external source of power. By keeping the metal to be plated in contact with another metal lower in the electromotive series it is often possible to increase the thickness of "immersion coatings," including tin. However, Mr. Howes informs us that such coatings are not generally referred to as immersion coatings.

(more Letters on p 256)

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MANUFACTURERS' LITERATURE

New Literature

Metal Castings. Advance Foundry Co., 8 pp, illus. Photographs show use of Strenes Metal castings as drawing and forming dies. (1)

Martempering Ajax Electric Co., 2 pp, illus., No. 164. "Deepest Martempering Furnaces Cut Distortion on Aircraft Weldments." (2)

Large Aluminum Extrusions. Aluminum Co. of America, 34 pp, illus. Describes Alcoa's 14,000-ton extrusion press. Shows advantages, production operations, quality control, major equipment, tools, design influence, examples of typical shapes and manufacturing limitations and tolerances. (3)

Austenitic Stainless Steels. Allegheny Ludlum Steel Corp. 10 pp. Details on chromium-nickel-manganese austenitic stainless steels, called the 200 series, that use less nickel than the 300 series but give high performance in many applications. (4)

Heat Resistant Parts. American Brake Shoe Co., Electro-Alloys Div., 6 pp, illus., No. T-227. Shows typical Thermalloy trays and fixtures, describes electro-alloy facilities and explains how proper design adds to service life. (5)

Aluminized Wire. American Chain & Cable Co., Inc., Page Steel & Wire Rope Div., 6 pp, illus., No. DH-537. Describes hot dip aluminum coated steel wire and wire products. Wire withstands forming operations and one-diameter wrap test without fracture of coating. (6)

Environmental Test Equipment. American Research Corp., 6 pp, illus, No. 55-A. Discusses features, specifications and dimensions of equipment used for testing under conditions of altitude, temperature, humidity, sand and dust. Also includes data on air and liquid chillers. (76)

Index of American Standards. American Standards Assn. 56 pp. Price list and index of 1600 American Standards. The 152 standards include: screw threads, bolts and nuts, and iron and steel pipe. (7)

Soldering Fluxes. Anchor Metal Co., Inc., 4 pp, illus. How to select the proper corrosive and noncorrosive fluxes for joining all types of metals. (8)

Arc Welding. Babcock & Wilcox Co., Tubular Products Div., 1 p, No. 155A. Data card summarizing various recommendations for arc welding various tubing steels. Indicates proper electrode to use and provides information about preheating and postwelding heat treatments. (9)

Nylon Resins. Belding Corticelli Industries, 17 pp. Technical bulletin on physical and chemical aspects of BCI 800 Series nylon. Product studies point up the series' versatility and potential applications. (10)

Bearing Material Chart. Bound Brook Oil-Less Bearing Co., 4 pp, illus. Easily read chart showing how to select the proper material for sintered bronze or iron bearings. Lists chemical, mechanical and work characteristics of a wide range of sintered bearing materials. (11)

Drawing Titanium. Brooks & Perkins, Inc., 6 pp, illus. Reprint discusses techniques for drawing and other forming methods used in making draws of unusual severity and depth. (12)

Sintered Metal Parts. Burgess-Norton Mfg. Co., 4 pp, illus. Describes equipment and facilities for making Quali-Sint sintered metal parts. Minimum tensile strength for these parts is 50,000 psi and minimum density is 6.2 gm per cu cm. (13)

Industrial Resins. Catalin Corp. of America, 8 pp, illus. Shows facilities for compounding urea, resorcinol, melamine, cresol and phenol formalde-

hyde resin formulations to specifications. These industrial resins are used for laminating, bonding, glueing and impregnating. (14)

Cap Screws. Cleveland Cap Screw Co., 4 pp, illus. Discusses torques for cap screws and lists recommended torques for Cleveland cap screws and place bolts. (15)

Molybdenum in Cast Iron. Climax Molybdenum Co., 8 pp, illus., Nos. 1, 2. Case histories on the use of molybdenum as an alloying element in gray iron castings. Tabulates the effect of adding different alloys to a single base iron and underscores the effectiveness and economic advantages of molybdenum. (16)

Plastics Properties Chart. Commercial Plastics & Supply Corp., 4 pp, illus. Chart showing mechanical, electrical, thermal and other properties of polyethylene, methacrylate, polystyrene, nylon, Teflon, Vinylite and acetate. (17)

Silicone Rubber. Connecticut Hard Rubber Co. 8 pp. Lists silicone rubber's outstanding properties and describes an extensive line of distributor handled stock items. (18)

Aluminum Bronze Castings. Continental Copper & Steel Industries, Inc., Niagara Falls Smelting & Refining Div., 6 pp, illus. Data on hardeners, fluxes, deoxidizers, special alloys and master alloys. (19)

Embossed Patern Metal. Croname, Inc. CroRoto Div., 6 pp, illus. Discusses use of stock embossed patterns for decorative trim and functional metal parts. Also describes production facilities and recommends finishes. (20)

Urethane Foams. Dayton Rubber Co., 15 pp, illus. Describes flexible as well as rigid Poly-Koolfoam synthetics, which have excellent insulation properties and resist flame and chemicals. Also shows typical products and manufacturing facilities. (21)

Hot Spray Paint Method. DeVilbiss Co., 8 pp, illus. Lists advantages of the hot spray paint method: improved finishes, material savings, fast application, easy spraying, uniform coating and reduced maintenance and overhead (22)

Chromium Plating. Diamond Alkali Co., Chromium Chemicals Div., 4 pp, illus. Fact-file folder on a chromium plating additive for decorative and hard chrome applications. (23)

Silicone-Glass Laminates. Dow Corning Corp., 4 pp, illus. Physical and dielectric properties of glass cloth laminates bonded with silicone resins. Also case history descriptions of a wide range of specific electric and electronic applications. (24)

Neoprene. E. I. du Pont de Nemours & Co., Inc., Elastomers Div., 8 pp, illus. *Neoprene Notebook* has article on the meaning of "oil resistance" in rubber. Also covers recent applications of neoprene. (25)

Polyester Film. E. I. du Pont de Nemours & Co., Inc., Film Dept. Wilmington 98, Del. Convenient slide rule that compares the cost and properties of Mylar polyester film with those of other materials. Request from Du Pont.

Permanent Mold Castings. Eaton Mfg. Co., Foundry Div., 18 pp, illus. Describes Eaton permanent mold process for producing gray iron castings in volume in mechanically operated metal molds without the application of pressure. (26)

Self-Locking Nut. Elastic Stop Nut Corp. of America, 6 pp, illus. Where and how to use Esna Elastic stop nuts, which are locked on the bolt by the gripping action of the elastic collar. (27)

Foam Vinyl. Elastomer Chemical Corp., 4 pp, illus. News Letter contains reports on new applications of Vinyl foam and lists its physical properties and advantages. (28)

Screws. Elco Tool & Screw Corp., 4 pp, illus. Condensed catalog with general information on all principal types of screws, bolts, threaded products and cold headed products. (29)

Glass Fabrics. Flightex Fabrics, Inc., 4 pp. Specification guide for 48 Flightex glass fabrics. (30)

Water Base Adhesives. Flintkote Co., Industrial Products Div., 4 pp, illus., I-F No. 46. Characteristics and advantages of water base adhesives and protective coatings for industrial insulations. Products include asphalt, tar, resin and rubber base emulsions and dispersions. (31)

Metal Powder Parts. Globe Indutries, Inc., Supermet Div., 8 pp, illus. Design information on Supermet powder metal process, which provides ultimate high tensile and yield strengths up to 200,000 psi. Powder metal parts can be made to the same or in many cases lower tolerance margins than machined parts. (32)

Rigid Plastics Pipe. B. F. Goodrich Co., Plastic Products Div., 8 pp, illus. Describes high impact rigid Koroseal pipe, fittings and valves. Tells how pipe is installed, reviews product applications and tabulates physical properties. (33)

Low Temperature Brazing. Handy & Harman, 4 pp, illus. New applications and recent developments in Easy-Flo low temperature silver brazing alloy. (34)

Perforated Metal Sheets. Harrington & King Perforating Co., Inc., 6 pp, illus. Describes sizes, gages and materials of perforated metal sheets carried in stock. Patterns are shown at actual size. (35)

Die Casting Alloys. Henning Bros. & Smith, Inc., 23 pp, illus. Information on design requirements of zinc base die casting alloys. (36)

Metallized Films. High Vacuum Metals, Inc., 6 pp. Custom fabrication of metallized Mylar and other metallized films—laminating, embossing, die cutting, etc. (37)

Polyester Foam. Hudson Foam Plastics Corp., 6 pp, illus. Describes a nonlatex, flexible polyester foam said to have exceptional stability and uniformity. Fire retardant, lightweight, stable and easily fabricated, Cush-N-Foam takes more than 18.8 lb per sq in. pull before parting. (38)

Aluminum Impact Extrusions. Impax, Inc. 4 pp, illus. How aluminum impact extrusion can reduce a complex assembly of many components to a single, high strength, smooth surfaced unit. Shows advantages of impacting over machining, drawing, forging, casting and welding. (39)

Polyester Resins. Interchemical Corp., Finishes Div., 16 pp. Data on several grades of polyester resins, color concentrates, filled resins, binders and other accessories. (40)

Nickel Alloys. International Nickel Co., Inc., illus. Booklet on properties of nickel alloys at low temperatures. Data cover only those materials in current use. (41)

Pipe and Block Insulation. Johns-Manville, 12 pp, illus. Describes Thermobestos pipe and block insulation made of hydrous calcium silicate. It is used for hot outdoor piping and process equipment operating at service temperatures up to 1200 F. (42)

Industrial Tapes. Johns-Manville, Dutch Brand Div., 20 pp, illus. Shows the many uses of Dutch Brand industrial tapes and related products. (43)

Fluorocarbon Products. M. W. Kellogg Co., 8 pp, illus. Forms, properties and uses of Kel-F fluorocarbon products—plastic resins, dispersions, oils, waxes, greases, elastomers printing inks and chemicals. (44)

Glass Fiber Roving. L.O.F. Glass Fibers Co., 8 pp, illus. Properties and specifications of Garan, Vitron and chrome roving for rod stock, molding compounds, preforming, mat, woven roving and other applications. (45)

Fiberglass-Epoxy Tubing. Lamtex Industries Inc., 4 pp, illus. Data on Tuff-Tube, laminated fiberglass-epoxy tubing, now used for electronic fuel gages in aircraft. Other applications include waveguides, electrical conduit, capacitor jackets and helicopter rotorshaft housings. (46)

Fatigue-Proof Steel Bar. La Salle Steel Co., 20 pp, illus. Information on new Fatigue-Proof steel bar that has high strength — 140,000 to 150,000 psi — without heat treating. (47)

Fluorescent Molding Resins. Luminous Resins, Inc. Sample book containing color chips of Derbylite fluorescent materials. These molding compounds are available in: polystyrene, polyethylene, polyesters, cellulose acetate, polyvinyl, acrylic, butyrate and reinforced fiberglass sheets. (48)

Electrical Insulating Resins. Minnesota Mining & Mfg. Co. 4 pp, illus. Describes Scotchcast brand synthetic resins for electrical applications. Shows typical applications with data on flexibility, viscosity, pot life, cure times and available forms. (49)

Urethane Coatings. Mobay Chemical Co., 55 pp, illus. Comprehensive manual on the preparation and use of Mondur/Multron urethane coatings

Manufacturers' Literature

in electrical applications. Discusses varnishes and wire enamels and includes handling precautions. (50)

Polyethylene Processing Tips. U. S. Industrial Chemicals Co., Div. of National Distillers Products Corp., 6 pp, graphs. File folder containing polyethylene processing tips covering increased production rates, tailor-made resins, reduction of warpage in injection molding and choice of the right resin for polyethylene wire coating. (51)

Impact Testers for Metals. National Forge & Ordnance Co., Testing Machine Div., 4 pp, illus., No. 561. Describes features of impact testers for metals. These compact, simplified units have convenient controls, do not require skilled operators and conform to ASTM standards. (52)

Vinyl Stabilizers. Metasap Chemical Co., subsidiary of Nopco Chemical Co., 6 pp, illus. Tabulates properties of stabilizers designed to protect vinyl products against heat and light, preventing embrittlement and loss of color and tensile strength. (53)

Self-Locking Fasteners. Nylok Corp., No. 11-B. Catalog of self-locking fasteners that have a nylon pellet inserted in the threaded area. Pellet locks in any position along the thread. It also acts as a sealant against liquid leakage. (54)

Custom Molded Rubber Parts. Parker Appliance Co., Rubber Products Div., 4 pp, illus., No. 5810. Describes special compounding service for custom molded rubber parts, shows various applications and explains how exclusive techniques have resulted in economical production. (55)

Formed Wire Products. Peerless Wire Goods Co., Inc., 8 pp, illus. How wire goods are made from the roll of wire to the completed product, resistance welded at all points of contact. Shows typical applications and describes services. (56)

Corrosion Proofing Materials. Pennsylvania Salt Mfg. Co., 8 pp, illus. Manual on corrosion proofing. Describes Corlok, a special silicate bonding material that resists sulfation and highly concentrated acids up to 1900 F for long periods. (57)

Aircraft Aluminum Extrusions. Pioneer Aluminum Supply Co., illus. Aircraft aluminum extrusion catalog. Contains more than 2000 different extruded shapes, weights and factors and a cross-reference section on extrusion die numbers of 23 airframe manufacturers. (58)

Electrostatic Spray Painting. Ransburg Electro-Coating Corp., 16 pp, illus. Typical on-the-line examples of the Ransburg No. 2 process of electrostatic spray painting, which saves paint and labor and reduces rejects. (59)

Forgings. Rome Mfg. Co. Div., Revere Copper & Brass, Inc., 12 pp, illus. Describes aluminum, brass and copper forgings and explains the advantages of die pressed forgings. Also contains charts showing the properties of various copper and aluminum base alloys. (60)

Coiled Precoated Metals. Roll Coater, Inc., 4 pp, illus. Folder contains samples of precoated metals so that the finish can be tested by bending, crimping or shearing. Process is explained by a series of photographs and captions. (61)

Steel Tubing. Joseph T. Ryerson & Son, Inc., 8 pp, illus., No. 12-6. Data on specially processed steel tubing and cold finished steel bars for hydraulic cylinders and fluid lines. (62)

Centrifugal Castings. Sandusky Foundry & Machine Co., 4 pp, illus. Installation of high frequency induction melting furnaces permits company to offer an extended range of services, compositions and products. Cylindrical castings, both ferrous and nonferrous, are available in diameters from 3 to 54 in. and lengths up to 327 in. (63)

Preload Indicating Washers. Standard Pressed Steel Co., 11 pp, illus. Describes automatic device for tightening bolt joints. Accuracy of PLI-Washer is reported to be ±10% as compared to 30% for conventional torque-wrench method of tightening. (64)

Large Diameter Thin-Wall Tubing. Superior Tube Co., 5 pp, illus., No. 4. Describes thin-wall tubing with ⅝ to 2¼ in. o.d. and wall thicknesses of 0.035 in. and less. Analyses and production limits are given for the tubing, which is made in both seamless and Weldrawn grades. (65)

Hard Precision Steel Rods. Thomson Industries, Inc., 5 pp, illus. Explains advantages of "60 Case" hardened and ground material (AISI 1060) for shafting, rolls, guide rods, etc. Made at high rates by special techniques and equipment, it is said to eliminate problems of erratic warpage, straightening and resultant grinding problems. (66)

Blind Rivet. Cherry Rivet Div., Townsend Co., 4 pp, illus., No. TL-118. Describes Versa-Rivet, a blind rivet that offers a wide grip range, positive hole fill, high clinch, positive inspection and uniform stem retention. One shank length is satisfactory for all thicknesses of material handled by any rivet diameter. (67)

High Temperature Alloy. Haynes Stellite Co., Div. of Union Carbide & Carbon Corp., 12 pp, charts. Data on Hastelloy alloy R-235, a wrought, nickel-base, aluminum and titanium-bearing, precipitation hardening alloy with good high temperature properties. Available as sheet, plate, bar stock, tubing, wire and billets for forging, the material can be welded by spot, roller-seam resistance, sigma and Heliarc methods. (68)

Expanded Metals. U. S. Gypsum Co., 8 pp, illus. Introduces four new expanded patterns available in carbon steel, aluminum and, in some meshes, stainless steel. Applications include chairs, screens, radio and television grilles, partitions, filter screens and sorting bins. (69)

Porcelain-Faced Plywood. U.S. Plywood Corp., 6 pp, illus. Describes Weldwood Porc-Lin-Ply panels. Panels consist of a porcelain facing with a laminated exterior plywood core and a metal sheet backing. Shows colors available and gives typical applications, installation instructions and specifications. (70)

Low Temperature Freezing Units. Webber Mfg. Co., Inc., 8 pp, illus. Information on complete temperature range testing units for production line and experimental testing. Units range from –165 to 350 F. (71)

Nylon-Rayon Fabric. Wellington Sears Co., Lantuck Dept., 16 pp, illus. Describes Lantuck, a nonwoven fabric designed for industrial uses. Made of nylon and rayon, the material has: balanced strength because of random distribution of fibers; unlimited fiber variety; and a flexible range of widths, weights, gages, densities and finishes. (72)

Magnetic Perforating Dies. S.B. Whistler & Sons, Inc., 21 pp, illus., No. M-45. Catalog of magnetic perforating dies for perforating materials up to and including ¼-in. thick mild steel. (73)

Liquid Neoprene Coatings. Wilbur & Williams Co., 4 pp, illus. Announces the availability of du Pont Neoprene in liquid form for brushing and spraying without usual shelf-life limitations. (74)

Extruded Plastics. World Plastex, 4 pp, illus. Describes facilities for making precision plastics extrusions in a wide variety of colors and formulas. All extrusions — rods, tubes, strips and special shapes—are made to order. (75)

Other Available Literature

Irons & Steels • Parts • Forms

Sintered Stainless Parts. Alloy Metal Powders, Inc., 4 pp. "Operational Steps in Producing Sintered Parts From Stainless Steel Powders." (80)

Circular Steel Parts. Cleveland Welding Div., American Machine & Foundry Co., 26 pp, illus. Describes the Cleve-Weld Process and shows how specialized production facilities and know-how can save money on circular steel parts. (81)

Stainless Steel Fastenings. Anti-Corrosive Metal Products Co., Inc., 64 pp. Catalogs more than 9000 stainless steel fastenings and gives prices (82)

Enameling Iron. Armco Steel Corp., 32 pp, illus. Describes sheet iron for porcelain enameling. Includes design and fabrication data and information on cleaning and pickling. (83)

Investment Castings. Austenal Laboratories, Inc., 12 pp, illus. Describes Microcast process and charts representative properties of investment cast alloys. (84)

Manufacturers' Literature

Nickel Plated Steel. Bart Mfg. Corp., 6 pp, illus. Lectro-Clad pipe now controls corrosion in water systems, in natural gas production and in the pulp and paper, organic chemical and inorganic chemical fields. (85)

Low Alloy Steel. Bethlehem Steel Co., 66 pp, illus., No. 353. Properties and features of Mayari-R steel for use in applications requiring high strength and good wear and corrosion resistance. (86)

Ferrous Castings. Campbell, Wyant & Cannon Foundry Co., 24 pp, illus. Describes facilities for producing gray iron and steel castings, and pictures a variety of actual production parts. (87)

Alloy Comparison Chart. Cannon-Muskegon Co. Comparison chart of AISI, SEA, ACI, AMS, WAD and PWA alloy specifications. (88)

Chromium-Nickel Alloy Steels. Carpenter Steel Co., 14 pp, illus. Carpenter No. 158 for case-hardening jobs and No. 5-317 for tough-tempering and hard-tempering jobs simplify selection problem and meet mechanical requirements for structural appilcations. (89)

Forgings. Cleveland Hardware & Forging Co., 38 pp, illus., No. 19A. Catalog of stock industrial and automotive forgings. (120)

Bolt and Forging Products. Columbus Bolt & Forging Co., 40 pp, illus. Describes facilities for producing assembly parts for the bolt and forging industries. (90)

Lead Treated Steel. Copperweld Steel Co., Steel Div., 8 pp, illus. Mechanical properties and applications of lead treated steels. (91)

Tool Steel. Crucible Steel Co., 47 pp, illus. "Tool Steel for the Non Metallurgist" presents a practical understanding of tool steels in nonmetallurgical terms. Includes a discussion of water and oil hardening steels, shock resistant steels, hot working steels and high speed steels. (92)

Shell Mold Castings. Electric Steel Foundry Co., 12 pp, illus., No. 205. Describes advantages of shell mold castings and illustrates castings made for various industries. (121)

Carbonyl Iron Powder. Antara Chemcials, Div. of General Aniline & Film Corp., 8 pp. Data on ten types of carbonyl iron powder. Includes graphs on properties. (93)

Ceramic Mold Castings. Lebanon Steel Foundry, 4 pp, illus. Process for producing close tolerance steel castings from ceramic molds. (94)

Wire Gage Chart. Little Falls Alloys, Inc. Chart for determining gage and footage readings in Brown & Sharpe (AWG) wire gages. (95)

Welded Assemblies. R. C. Mahon Co., 1 p, illus. Several examples show the capabilities of welding for construction of various assemblies. (96)

Malleable Iron. Malleable Founders' Society, 4 pp, illus., No. 52. New facts on the uses of malleable iron. (97)

Castings. Meehanite Metal Corp., 4 pp, illus. Reprint tells how cost of special pattern making can be eliminated by ordering cast bar stock in standard sizes. (98)

Chromium-Nickel Alloy Steel Powders. Metal Hydrides, Inc., 4 pp. Reprint on use of pre-alloyed chromium-nickel powders for strong, wear resistant products. (99)

Forgings for Autos. Pittsburgh Forgings Co., 4 pp, illus. Pictures forgings made for the automotive industry. (100)

Seamless Mechanical Tubing. Pittsburgh Steel Co., 198 pp, illus. Applications, cost analysis, production techniques, inspection and testing methods, tolerances, chemical composition, physical properties, machining techniques and reference tables for full range of seamless mechanical tubing. (101)

Coated Strip Steel. Thomas Strip Div., Pittsburgh Steel Co., 20 pp, illus., No. TS-101. Strip steel precoated with zinc, copper, brass, lead alloy, nickel or chromium, and having natural planished or buffed finishes and rolled in patterns. Booklet includes 8 samples. (102)

Knitted Wire Products. Alloy Metal Wire Div., H. K. Porter Co., Inc., 8 pp, illus., No. A-1. Describes design features of knitted stainless steel and nickel alloy wire. Applications include filters, liquid entrainment separators, shock isolation cushions and electronic weather stripping. (103)

Roll Formed Shapes. Roll Formed Products Co., 26 pp, illus. Shows simple and complex sections produced from both ferrous and nonferrous metals. (105)

Zinc Coated Steel. Sharon Steel Corp., 12 pp, illus. Physical properties of a hot dipped, zinc-coated strip steel. (107)

Spun Metal Parts. Spincraft, Inc., No. 3. Metal spinning and fabricating. Data on process and help in designing for economical production. (108)

Powder Metallurgy. F. J. Stokes Machine Co., 36 pp, illus. Clear, concise discussion of powder metallurgy including summary of process, applications, mechanical characteristics of powder metal parts, and design considerations. (109)

Stainless Strip. Superior Steel Corp., 32 pp, illus. Technical information on 20 types of stainless strip steel. Includes table on weight per lineal foot of strip steel for various thicknesses and widths. (110)

Steel Castings. Tempil Corp., 40 pp. "Recommended Practice for the Welding of Steel Castings." Comprehensive manual published by Steel Founders' Society of America. (111)

Wire Construction. E. H. Titchener & Co., 11 pp, illus. Study of 36 case histories shows how wire in product design cuts costs. (112)

Seamless Steel Tubing. Tube Reducing Corp., 4 pp, illus. Data on Rockdrawn small diameter seamless steel tubing. Sizes range from ⅛ to 1⅜ in. o.d. in a wide variety of wall thicknesses in carbon, alloy and stainless steels. (113)

To obtain literature listed on these pages, use the convenient prepaid post card on pp 69 and 70.

Prealloyed Steel Powder. Vanadium-Alloys Steel Co., 4 pp, illus. Describes alloy steel powder with high hardenability not obtainable with iron-carbon mixes. Typical applications include gears, bushings and piston rings. (114)

Ferroalloys. Vanadium Corp. of America, 24 pp, illus. "The Vancoram Review" presents technical articles on applications and developments in ferro metallurgy especially concerned with vanadium alloys. (115)

Weldments. Van Dorn Iron Works Co., 10 pp, illus. Facilities for producing weldments and other parts in all sizes. Examples show type of work done. (116)

Stampings. Variety Machine & Stamping Co., 4 pp, illus. Describes plant facilities and types of stampings produced. (117)

Stainless Steel Sheet. Washington Steel Corp., 12 pp, illus. Care and use of Type 430 MicroRold stainless steel sheet. Physical properties and analysis, relative corrosion resistance, fabrication and application. (118)

Steel Strip. Weirton Steel Co., 20 pp, illus. Characteristics of electrolytic zinc coated sheets and strip, high tensile steel and high carbon strip cold-rolled spring steel manufactured by Weirton. (119)

Nonferrous Metals • Parts • Forms

Aluminum, Stainless Steel. Aluminum Goods Mfg. Co., Contract Div., 21 pp, illus. "Service to Industry" lists wide variety of component parts made for government and industry. Technical services and finishing and fabricating facilities are also described. (124)

Phosphor Bronze. American Brass Co., 1 p, illus. Describes Anaconda's Duraflex, a fine grain phosphor bronze said to have an endurance limit 30% higher than ordinary phosphor bronze. (125)

Engineering Bronzes. American Crucible Products Co., 12 pp, illus. Includes complete data on facilities, technical information, case histories and applications of Promet bronzes. (126)

Electrolytic Copper Powders. American Metal Co. Ltd., 3 pp. Data sheets on specifications for electrolytic copper powders. (127)

Bearing Bronze. American Smelting & Refining Co., Continuous-Cast Products Dept., 6 pp, illus., No. 301. Presents in tabular form all continuous-cast stock sizes and weights for solid and hollow bronze bars ½ to 9 in. in dia. (128)

Precision Casting Process. Morris Bean & Co. 4 pp, illus. Describes Antioch process for producing castings that meet wave guide specifications in all bands. (129)

Castings. Eclipse-Pioneer Div. Foundries, Bendix Aviation Corp, 4 pp, illus. Discusses facilities for producing a variety of sand, die and permanent mold castings of magnesium and aluminum. (130)

Manufacturers' Literature

Duplex Tubing. Bridgeport Brass Co., 14 pp, illus., No. 1954. Explains use of Duplex tubes for heat exchangers and condensers in which internal and external corrosion conditions differ. (131)

Sintered Bronze. Bunting Brass & Bronze Co., 12 pp, illus., No. 56P. Information on stock bearings, washers and bars made of sintered bronze. (132)

Bimetals. W. M. Chace Co., 36 pp, illus. Describes and explains 22 uses of bimetals as actuating elements in temperature responsive devices. (133)

Die Casting. Dollin Corp., 16 pp, illus. Booklet describes plant and facilities for die castings. (134)

Resistance Alloys. Driver-Harris Co., 8 pp, illus. Four bulletins describe an 0.0005-in. dia enamelled wire for resistors; an alloy with a specific resistance of 1000 ohms per cmf; a new heating element alloy; and a new oxidation resistant, thermocouple for high temperatures. (135)

Titanium. E. I. du Pont de Nemours & Co., Inc., Pigments Dept., 8 pp, illus. Up-to-date data on properties of titanium and methods of fabricating the metal. (136)

Electroforming. Gar Precision Parts, Inc., 4 pp, illus. Process permits exact reproduction of intricate details on sheet or complex forms using permanent or expandable mandrels. (137)

Investment Castings. Gray-Syracuse, Inc., 4 pp, illus. Parts of precision cast brass, bronze, beryllium copper and steel. (138)

Beryllium Copper Springs. Instrument Specialties Co. Inc., 16 pp, illus., No. 9A. Data on precision beryllium copper springs. Explains Micro-Processing, describes engineering services and shows typical compression, flat and strip springs and contact strips and rings. (139)

Aluminum Extrusions. Kawneer Co., Aluminum Mill Products Div., 4 pp, illus. Describes completely integrated (pig through extrusion) facilities for producing shapes, rod, bar and tubing. (141)

Tin. Malayan Tin Bureau. *Tin News*, a monthly publication of the Malayan Tin Bureau, reviews market situation, tin uses and political developments affecting the supply of tin. (142)

Titanium. Mallory - Sharon Titanium Corp., 8 pp, illus. How to design away corrosion with titanium. Table shows corrosion ratings for titanium when exposed to corrosive agents. (143)

Die Castings. Monarch Aluminum Mfg. Co. File data on aluminum and zinc die castings and aluminum mold castings showing applications, advantages and facilities for making them. (144)

Copper Alloys in Rod Form. Mueller Brass Co., 28 pp, illus. Engineering data on copper base-alloys are given, together with description of new company facilities. (145)

Aluminum Core. Narmco Metlbond Co., 6 pp. Formable core material for aluminum sandwich constructions where small-radius curves are needed. (146)

Brass Powder Parts. New Jersey Zinc Co., 4 pp, illus. Outlines appilcations for brass powder sintered parts, emphasizing tripper flywheel in advanced-type camera. (147)

Precision Castings. Ohio Precision Castings, Inc., 12 pp, illus. Shows numerous examples of brass, bronze, aluminum and beryllium copper plaster mold castings. (148)

Thin Metal Strip. Penn Precision Products Inc., 8 pp, No. 7. Case histories and data on thin gage (down to 0.5 mil) beryllium copper, phosphor bronze, nickel silver, chromium copper, 17-7PH stainless invar and magnetic alloy strip. (149)

Aluminum Castings. Permold Co., illus. Shows how continuous scientific control of aluminum casting quality saves time and money. (150)

Precision Metal Parts. REF Mfg. Corp., 10 pp, illus. Facilities for producing precision parts and assemblies for aircraft and electronic use. (151)

Titanium. Rem-Cru Titanium Inc., 12 pp. Data sheet on Rem-Cru C-130AM. (152)

Metal Designs. Rigidized Metals Corp., 2 pp. Folder contains four metal samples. Company has more than 40 standard patterns, some of which are shown in photographs. (153)

Nonferrous Alloys. Riverside Metal Div., H. K. Porter Co. A reference and guide to specifying phosphor bronze, nickel silver, cupro nickel and beryllium copper. (154)

Aluminum, Magnesium Castings. Rolle Mfg. Co., 58 pp., illus. Guide to design and specification of aluminum and magnesium sand, permanent mold and die castings. Discusses advantages and disadvantages of casting methods and gives properties of common aluminum and magnesium casting alloys. (155)

Aluminum Castings. Solon Foundry, Inc., 4 pp, illus. Description of company's plant and facilities for producing aluminum castings. (156)

Stamping and Perforating. Standard Stamping & Perforating Co., 114 pp, illus. Catalog of standard stamped and perforated patterns. (157)

Electronic Materials. Sylvania Electric Products, Inc., Tungsten & Chemical Div. Series of data sheets on tungsten, molybdenum, semiconductor, plated wire, chemical and phosphor products. (158)

Brass Pressure Die Casting. Titan Metal Mfg. Co., 4 pp, illus. Outlines economical uses of brass pressure die castings as fabricated assembly parts. (159)

Precision Castings. Universal Castings Co., 4 pp, illus. Technique of pouring at low temperatures and under vacuum as used in casting precision impellers. (160)

Super Alloys. Universal-Cyclops Steel Corp., 20 pp, illus. High strength, corrosion resistant alloys for gas turbines, turbo-superchargers rockets and guided missiles. (161)

Thermometals and Special Alloys. H. A. Wilson Co., 2655 U.S. Route 22, Union, N. J., 192 pp price $3.00. New Blue Book on thermostatic bimetals, sintered metals, electrical contact materials, composite and laminated metals and special alloys. Provides design data, graphs, formulas and properties and applications of hundreds of materials. Request from Wilson on company letterhead.

Light Metal Forgings. Wyman-Gordon Products Corp., 4 pp, illus. Announces the availability of large size light alloy forgings, particularly those of magnesium and 7075 aluminum. (162)

Nonmetallic Materials • Parts • Forms

Rubber-Metal Parts. Acushnet Process Co., 7 pp, illus. Use of Apcotite process for bonding natural and synthetic rubbers, including silicones, to metals. (167)

Plastics vs Reagents. American Agile Corp. Compatibility or noncompatibility of reagents with such thermoplastic materials as polyethylene unplasticized polyvinyl chloride, high impact polyvinyl chloride and high tensile, high temperature polyethylene. (168)

Molding Compound. American Cyanamid Co., 6 pp. Technical data on glass fiber - filled melamine - formaldehyde molding material. (169)

Felt Samples. American Felt Co., 8 pp. SAE felt standards and specifications, with samples exhibiting 16 different grades. (170)

Extruded Plastics. Anchor Plastics Co., 12 pp, illus. Applications of thermoplastic rods, tubes and shapes. Summary of properties of plastics materials with usage table. (171)

Fiberglass Reinforced Plastics. Apex Electrical Mfg. Co., 4 pp, illus. Case histories of custom molded fiberglass parts featuring pressure vessels. (172)

Plastisols. Arbonite Corp., Information file on plastisols and plastics protective coatings and linings. (173)

Nonmetallic Linings. Automotive Rubber Co. Eleven actual specimens of rubber and plastics compounds used in most corrosion and abrasion resistant lining work done by this company on tanks, vessels, pipe, fittings, duct work, fans and other equipment. (174)

Molding Compounds, Resins and Cement. Borden Co., Durite Div., 8 pp, illus., No. 10M. General properties and uses of Durite specially prepared phenolic molding compounds, resins and cements. (150)

Clear Rigid Plastics. Cast Optics Corp., 12 pp, illus. Lists uses, advantages and properties of five optically clear rigid plastics sheets. Also explains engineering service. (175)

Injection Molding Cellulosics. Celanese Corp. of America, Plastics Div., 7 pp, illus., No. A-16. "Fundamentals of Injection Molding Cellulosics." (176)

Contact Pressure Laminating Resins. Ciba Co. Inc., 17 pp, No. 1. Data on Araldite contact pressure laminating resins. Includes technical and electrical properties, charts and tables, mold preparation, glass fiber reinforcement and manufacturing procedures. (177)

Fiberglass Reinforced Parts. Clearfield Plastics, Inc., 22 pp, illus. Facilities for producing molded contoured parts.

Suggests design and specification techniques. (178)

Vacuum Forming. Coating Products, 2 pp, illus. Bulletin on vacuum forming method of molding thermoplastic sheets. (179)

Molded and Extruded Rubber. Continental Rubber Works, 8 pp, No. 100. Dimensions of molded and extruded rubber with cross sectional illustrations. Also condensed SAE and ASTM specification chart. (180)

Teflon Products. Crane Packing Co., 12 pp, illus., No. T-110. Facts on Chemlon products made from Teflon. Describes packings, gaskets, O-rings, flexible bellows and sheets, rod tubing and tape. (181)

Electrical Insulating Tapes. Dobeckmun Co. 4 pp, illus. Describes various electrical insulating tapes made from Mylar, cellulose acetate, cellulose acetate butyrate or cellulose triacetate bases, either alone or laminated to other materials. Typical applications shown. (182)

Thermoplastics. Dow Chemical Co., 20 pp, illus. Properties of forms of Styron, Ethocel, Saran and Vinyl supplied by Dow. Illustrates applications and outlines Dow's technical service facilities. (183)

Teflon. Ethylene Chemical Corp., 8 pp, illus. Complete data on a variety of molded and extruded Teflon parts, sheets, rods and tubing. Includes table of properties. (184)

Synthetic Rubber. Firestone Tire & Rubber Co., Synthetic Rubber & Latex Div. Information on FR-S, a new synthetic rubber developed by improved techniques, new measuring devices and scientific methods of control. (185)

PVC Pipe, Valves, Fittings. Peter A. Frasse & Co., Inc., 8 pp, No. 13. Describes rigid unplasticized polyvinyl chloride pipe, fittings and valves. Covers corrosion resistance, general properties, fabricating characteristics and economies. (186)

Reinforced Wood. Gamble Bros., Inc., 4 pp. Why wood coated with high strength thermoplastic has increased impact resistance and durability. (188)

Plastics Products. General American Transportation Corp., Plastics Div., 10 pp, illus. Brochure shows plant facilities for production from blueprint through assembly and packing. Also lists wide variety of molded plastics. (189)

Glass Bonded Mica Insulation. General Electric Co., Chemical Div., Plastics Dept., 23 pp, illus. Manual on Mycalex, a glass bonded mica. (190)

Electrical Insulating Materials. General Electric Co., Laminated & Insulating Prods. Dept., 8 pp, illus. Lists insulating materials, including varnishes, finishes and mica mat. Properties and applications given. (191)

Plastic-Faced Plywood. Georgia-Pacific Plywood Co., 14 pp, illus. Advantages of GPX plastic-faced plywood, used for cabinets, industrial counters, assembly line tables, etc. (192)

Oil Resistant Rubber. Goodyear Tire & Rubber Co., Inc., Chemical Div., 1 p. Data sheet on Chemigum N3, a butadiene-acrylonitrile copolymer for use with aromatic fuels or gasoline. (193)

Injection Molded Plastic. Gries Reproducer Corp. 4 pp, illus. Illustrates how design engineers can solve planning and production problems with tiny thermoplastic parts. (194)

Polyvinyl Chloride. HM. N. Hartwell & Son, Inc. 6 pp, No. 4B. Facts about Boltaron PVC used for sheets, bar stock, pipe fittings, pipe blocks, welding rod and valves. (195)

Electrical Tapes. Kendall Co., Polyken Sales Div., 4 pp, No. P6-1. Polyethylene, vinyl, plastic-coated cloth and cloth tapes for electrical applications. (196)

Glass and Ceramic Parts. Mansol Ceramics Co., 16 pp, illus. Glass preforms for hermetic seals, adhesives, steatite preform and multiform production facilities. (197)

High Impact Thermoplastic Resin. Marbon Corp., 20 pp, No. CY-2. Processing recommendations, physical data, chemical resistance data and results of aging tests for Cycolac, a resinous polymer in which the basic material is styrene. (198)

Reinforced Wood. Met-L-Wood Corp., 15 pp, illus., No. 521. Describes combined wood and metal sheets, providing light weight and high strength. (199)

Fiberglass Reinforced Plastics. Molded Fiber Glass Co., 16 pp, illus. Describes custom molding services. Lists fabricating operations and mechanical, electrical and chemical properties of molded fiberglass. (200)

Carbon Specialties. Morganite, Inc., 12 pp, illus. Design data reference for carbon specialties, including chemical and physical properties, and typical blank sizes and parts. (201)

Glass Bonded Mica. Mycalex Corp. of America, 24 pp, illus. Design information for parts to be machined from glass bonded mica. (202)

Vulcanized Fibre, Laminates. National Vulcanized Fibre Co., 4 pp, illus. Properties and uses of vulcanized fibre, a converted cotton cellulose, and Phenolite laminated plastics, a group of thermosetting high pressure laminates. (203)

Nonmetallics. Polymer Corp. of Pennsylvania, 4 pp, illus. Describes properties and characteristics of a line of nylon, Teflon and specialty nonmetallics. (204)

Rubber. Roth Rubber Co., 1860 S. 54 Ave., Chicago, Ill. Actual rubber samples with hardness from 5 to 100 durometer. Accompanied by ASTM specifications and list of uses for each sample. Request Rubber Sampler No. MM3 from Roth on company letterhead.

Polystyrene Rolls and Sheets. Plastics Div., Seiberling Rubber Co., 2 pp. Covers availability, specifications, physical properties, chemical resistance and adhesives for high impact polystyrene calendered rolls and sheets. (206)

To obtain literature listed on these pages, use the convenient prepaid post card on pp 69 and 70.

Plastics Moldings. Sinko Mfg. & Tool Co., 4 pp, illus. Facilities for producing molded parts and products. Automatic injection molding machines have capacities ranging from 4 to 60 oz. (207)

Vulcanied Fibre Products. Spaulding Fibre Co., 36 pp, illus. Vulcanized fibre sheets, rods and tubes; fabricated parts; electrical insulating materials; laminated thermosetting plastics; motor insulation; fibre board and transformer board. Physical, mechanical and electrical properties of all materials in chart form. (208)

Rubber. Sun Rubber Co., 22 pp, illus. Facilities for processing, curing and finishing rubber products. (209)

Machining Laminated Plastics. Synthane Corp., 6 pp, illus. Recommended techniques for common machining operations on laminated plastics. Includes properties and design hints. (210)

Fabricating Laminated Plastics. Taylor Fibre Co., 15 pp. Reprints of NEMA authorized engineering information, "Recommended Practice for Fabricating Laminated Plastics." (211)

Friction Materials. Thermoid Co., Industrial Friction Div., 4 pp. Discusses factors to be considered in selecting friction materials and presents a chart with extensive data on brake linings and clutch facings. (212)

PVC Parts. Tube Turns Plastics, Inc., 6 pp, illus. How custom molded parts of unplasticized polyvinyl chloride solve corrosion and weathering problems. Tabulates PVC's resistance to various materials and shows representative products. (213)

Neoprene Foam. Toyad Corp., 12 pp, illus. Shows applications and manufacture of Toyad neoprene foam as a cushioning material. Foam is resistant to flame, solvents, heat, aging, mildew, tearing and abrasion. (214)

Teflon. U. S. Gasket Co., No. 300. Tables and descriptive matter on chemical, electrical, thermal and mechanical properties of Teflon. (215)

Synthetic Rubber Products. Western Felt Works, Acadia Synthetic Products Div., 6 pp, illus. Shows various types of molded, extruded, roll die cut and lathe cut synthetic rubber parts and sheets. (216)

Sealing Design. Franklin C. Wolfe Co., Inc., 4 pp, illus. Describes facilities and products for sealing bolts, studs, rivets and flanges. (217)

Finishes • Cleaning and Finishing

Metal Protection, Paint Bonding. American Chemical Paint Co., 4 pp, illus., No. 3d/Am. Protective inorganic finishes to improve paint adhesion and corrosion resistance, and to facilitate metal forming operations. (222)

Hot Dip Galvanized Coatings. American Hot Dip Galvanizer's Assn., Inc., 16 pp, illus. Description of hot dip galvanizing process in industrial and consumer applications. (223)

Manufacturers' Literature

Casting Impregnation. American Metaseal Mfg. Corp., 8 pp, illus. Equipment and impregnants for batch impregnation of porous castings. Lists properties and applications. (224)

Plastics Finish. John L. Armitage & Co., 8 pp. Information on Armorhide, a textured plastics finish resembling leather. (225)

Hard Facing. Cleveland Hard Facing, Inc., 4 pp, illus. Service for hard facing parts subject to intense wear conditions. (226)

Enameled Metal Strip. Coated Coils Corp., 4 pp, illus. Describes coiled enameled metal strip supplied in widths up to 30 in. Strip can be put through operations without damaging the coating. (227)

Spray Painting. Conforming Matrix Corp., 5 pp, illus. Description, uses and advantages of this firm's spraying masks, mask washing machine and spray painting equipment. (228)

Chromate Sealer. Conversion Chemical Corp., No. P-40. How to use Kenvert No. 40, a chromate sealer for protecting aluminum against corrosion. (229)

Vapor-Spray Degreasers. Detrex Corp., 4 pp, illus. Open top degreasers for pure vapor degreasing, spray flushing with oil-free solvent distillate and final pure rinse. (230)

Aluminum Finishing. Diversey Corp., 4 pp. Lists cleaning and finishing equipment for aluminum. (231)

Solid Film Lubricants. Electrofilm, Inc., 4 pp, illus. Where Electrofilm solid film lubricants should be used and how they reduce friction and increase wear life. (232)

Metallized Ceramic Coating. Frenchtown Porcelain Co., 4 pp, illus. Data on Molcote, metal-to-ceramic coating, that may be hard soldered up to 2200 F. (233)

Paint for Metal. Glidden Co., 20 pp, illus. Displays application of Nubelite, an industrial paint finish for any metal product. (234)

Sprayed Metals. Metallizing Engineering Co., Inc., 6 pp, illus, No. 120. Shows a wide range of applications of metallizing in the production of electrical and electronic equipment. (235)

Silicone-Base Finish. Midland Industrial Finishes Co. Brochure describes silicone-base finish, said to resist heat at 500 F without discoloration. (236)

Stripper. Northwest Chemical Co., 1 p. A liquid stripper to remove organic finishes from plastics. (238)

Rust and Paint Remover. Oakite Products, Inc., 2 pp. How Rustripper removes paint, phosphate coatings, rust and oil in one operation. (239)

Industrial Brushes. Pittsburgh Plate Glass Co., Brush Div., Dept. W-4, 3221 Frederick Ave., Baltimore, Md. Case histories indicate economies available to users of Pittsburgh brushes. Request on company letterhead.

Metal Finishing. Roto-Finish Co., 6 pp, illus. Folder describes precision finishing process and various types of machines developed for diverse job requirements. (243)

Electroplating Data Chart. Technic; Inc. A readable 8½ x 11 in. chart giving electroplating data on precious metals such as gold, palladium, platinum, rhodium and silver. (245)

Corrosion Resistant Coatings. Specialty Coatings, Inc., Div. of Thompson & Co., 6 pp, illus. Examples of how Vinsynite Pretreatment was used in finishing six different types of metal products for good paint adhesion and corrosion resistance. (246)

Aluminum Coating. Turco Products, Inc. Information on an aluminum surface coating process that meets MIL-C-5541. Stops aluminum corrosion, insures paint adhesion and provides an ornamental finish. (247)

Methods & Equipment

Corrosion Inhibitor. Solvay Process Div., Allied Chemical & Dye Corp., 17 pp, illus. Use of sodium nitrite in corrosion prevention. (252)

Hardness Testing. Wilson Mechanical Instrument Div., American Chain & Cable Co., Inc., 12 pp, illus., No. DH-328. Describes Tukon Testers for micro and macro hardness testing. (253)

Heat Treating Equipment. American Gas Furnace Co., 140 Spring St., Elizabeth, N. J., 24 pp, illus. No. C-1304. Blow pipes, forges, pot furnaces, brazing and industrial heating machines. Request from American Gas on company letterhead.

Forged and Rolled Rings. Alco Products, Inc. 16 pp, illus., Nos. SF-1, SF-2. Describes advantages and applications of seamless forged and rolled rings. (254)

Silver Brazing. American Platinum Works, 16 pp. Manual on selective fluxing for low temperature silver brazing. (255)

Testing Machine. Baldwin-Lima-Hamilton Corp., 12 pp, illus., No. 4401. Hydraulic machines with capacities from 10,000 to 5,000,000 lb are described, including standard and special types of vertical and horizontal machines. (256)

Nondestructive Sorting. J. W. Dice Co., 1 p, illus., No. 2007. Describes Model CE Cyclograph for nondestructive sorting of mixed metals by metallurgical characteristics. (257)

Industrial Radiography. E. I. du Pont de Nemours & Co., Inc., Photo Products Dept., 24 pp, illus. x-ray films, chemicals and screens for industrial radiography. Charts evaluate basic characteristics of x-ray films and give optimum processing recommendations. (258)

Atmosphere Generators. Gas Atmospheres Inc., 6 pp, illus, Nos. N-452, 1-552. Describes features and applications of inert atmosphere generators and nitrogen atmosphere generators. (259)

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Furnace Temperature Indicator. Claud S. Gordon Co., 2 pp, illus. Describes device that quickly indicates any deviation from desired furnace temperature. (260)

Inserts. Groov-Pin Corp. Self-tapping insert used as original equipment and for salvage and repair of stripped threads. (262)

Induction Heating Generators. Induction Heating Corp., 4 pp, illus. Technical data and case histories with applications of 2½- and 3½-kw induction heating generators. (263)

Tablet Presses. Kux Machine Co., 4 pp, illus. Tableting presses for production of powdered metal and ceramic parts. (264)

Electric Furnaces. Pereny Equipment Co., 3 pp, illus., No. 4A. Advantages and illustrations of typical electric furnaces and kilns. (265)

Pyrometers. Pyrometer Instrument Co., Inc., 8 pp, illus., No. 175. Catalog of optical, micro-optical, radiation, immersion, surface and indicating pyrometers for precision temperature measurements. (266)

Lock Screw Fasteners. Russell, Burdsall & Ward Bolt & Nut Co., 3 pp, illus. Advantages and dimensions of spinlock screws. (267)

Wax Injection Presses. Alexander Saunders & Co., 8 pp, illus. Specifications and prices on wax injection presses for investment casting. (268)

Tensile Testing Machines. Scott Testers, Inc., 6 pp, illus., No. 55. Shows wide assortment of testing machines for determining tensile strength of materials such as rubber, paper, wire and thread. (269)

Lock Fasteners. Simmons Fastener Corp., 4 pp, illus. Details on five quickly installed fasteners — Dual-Lock, Link-Lock, Quick-Lock, Roto-Lock, Spring-Lock—that offer design flexibility, strength, positive locking and smooth fastening. (270)

Engineering Tables. U. S. Testing Co., Inc., 1415 Park Ave., Hoboken, N.J., 109 pp, illus. Selected chemical, physical, engineering, plastics, bacteriological, leather, psychometric and textile tables and charts arranged for easy reference. Request from U. S. Testing Co. on company letterhead.

Vacuum Melting. Utica Metals Div., Utica Drop Forge & Tool Corp., 8 pp, illus. Production and testing equipment, and progress made by Utica in taking vacuum melting out of the laboratory and into production. (274)

Heat Treating Furnaces. Waltz Furnace Co., illus. Describes types of industrial furnaces for heat treating, enameling, cyaniding and annealing in controlled and regular atmospheres. (275)

Heat Treating Furnaces. Industrial Heating Dept., Westinghouse Electric Corp., 38 pp, illus., No. B-5459. Complete description of Westinghouse furnaces—large and small, gas and electric. (276)

Electric Radiant Panels. Edwin L. Wiegand & Co., 6 pp, illus., No. CS605. Folder includes a variety of applications of Chromalox electric radiant panels. (277)

One Point of View:

Needed: more design data on reinforced plastics

Reinforced plastics are useful and versatile engineering materials. But because of an insufficient body of engineering and design data, their selection for engineered parts and products has been restricted in many fields. This lack of adequate engineering information also has resulted in some misapplications and poor designs.

To develop engineering information on reinforced plastics and to make it available in a usable form for engineers and designers is no small task. Because they are heterogeneous materials, their end properties are influenced by a great many variables. Also, the method of fabrication and the control over it directly affects the properties of the finished part (see article, p 118). Because of these many variables, it is important to develop an organized approach and to break down the job into manageable portions.

An organized approach

An outstanding example of an organized approach is the program recently established by Owens-Corning Fiberglas Corp. They have organized a Reinforced Plastics Engineering Development Department for the purpose of planning and implementing projects that will provide necessary engineering data for the design of reinforced plastics products. This development group has a number of specific projects under way, including a fundamental study of reinforced plastics, but only two concern us here.

Design manuals

Perhaps the most important one is their plan to develop a standard for design manuals on reinforced plastics in many fields of application. A manual is being currently produced for the marine field. But this first manual will be more than a design and engineering guide for one field. It will serve as the model for others to consider in preparing manuals. Also, in the course of its preparation they are learning what kind of property data and design information is needed, what is already available, and what must be developed. In a series of statistically designed test experiments to provide necessary data they will have test panels prepared and tested under known conditions. Finally, they hope to develop a format so that in future manuals engineering data will be presented in standard form.

Help available

The other project is concerned with design itself. Many present and potential fabricators and users of reinforced plastics do not have a large enough production to support a staff capable of investigating the suitability of these materials for new applications. Owens-Corning has surveyed the sources of technical talent that exist and, where needed, could provide design advice. Companies with products for which reinforced plastics appear suitable can get assistance from a pool of experienced engineering talent which includes several universities.

We believe this program is a promising step toward filling the need for more engineering data about plastics. It warrants careful consideration by everyone concerned with the production and use of reinforced plastics.

***Large or intricate shapes** can be made from the new material which is fabricated by conventional methods.*

New method of self-bonding has created an . . .

Improved Silicon Carbide for High Temperature Parts

Compared to conventional silicon carbide refractories, this new material offers:

Higher flexural strength

Higher stiffness

Lower permeability

Better thermal properties

Higher abrasion resistance

by K. M. Taylor, *Senior Engineer, Carborundum Co.*

■ A new, highly dense silicon carbide material overcomes many of the failings of older silicon carbide bodies. Using silicon carbide itself as the bonding material, so-called KT silicon carbide has an average bulk density of about 95% of theoretical and a minimum silicon carbide content of approximately 95%.

End properties of the new ceramic material include unusually high thermal conductivity, low thermal expansion, low permeability, high strength at elevated temperatures, outstanding abrasion resistance, chemical inertness, light weight, high emissivity and low absorption of thermal neutrons. Because it is formed by

conventional methods such as pressing in steel molds, casting or extruding, large intricate shapes can be readily made.

This unique combination of properties suggests that the material could be used advantageously in such applications as check valves for handling corrosive liquids; linings for ball mills; heat exchangers for high temperature furnaces; pumps for die casting machines; combustion tubes; and fuel elements and structural parts for gas cooled nuclear reactors.

Composition

KT silicon carbide parts can be made from commercial or high purity silicon carbide grain in a variety of grit sizes. After forming, the parts are subjected to a special high temperature treatment that produces a dense self-bonded body. Since crystal growth occurs during the process, the surface of the material is rather rough. However, a smooth, dense surface can be produced by rough grinding or polishing.

Silicon carbide content of the material ranges from about 95 to 98%. Chief impurities, as indicated in Table 1, are free silicon, free carbon, iron and aluminum. The iron and aluminum contents depend on the purity of the silicon carbide used. If pure silicon carbide is used, the only impurities are about 3% silicon and about 0.2% free carbon.

Physical properties

True density of silicon carbide is 3.22 gm per cu cm. Bulk density of present KT ware ranges from 3.0 to 3.15 gm per cu cm. Under optimum conditions, parts of 98% purity can be produced with a density of about 98% of theoretical. This high density results in a low permeability. A thin-wall tube of 5/16 in. o.d. and 3/16 in. i.d. produced from KT silicon carbide having maximum grain size of 100 mesh was found to be impervious to helium under 160 psi pressure at room temperature.

TABLE 1—COMPOSITION OF KT SILICON CARBIDE, %

Free silicon	1.5 - 4.0
Free carbon	0.1 - 0.5
Iron	0.05- 0.5
Aluminum	0.08- 0.3
Silicon carbide	98.27-94.7

The Bond in Silicon Carbide

Many of the limitations of silicon carbide refractories have been related to the bonding material. Four major types of bonds have been used.

The *silicate bond*, which is the oldest and most widely used, produces an excellent refractory for many purposes. However, depending upon its specific composition, this bond softens at 2200 to 2750 and is attacked by certain chemicals. Also, silicate-bonded silicon carbide materials are porous.

Silicon nitride-bonded silicon carbide provides considerable improvements and has gained acceptance as a premium material for special uses (see Wroten, M&M, Nov '54, p 83). It has higher strength at high temperatures than silicate-bonded silicon carbide. It can be made to closer tolerances, is superior in thermal shock resistance and is more resistant to certain materials. However, silicon nitride is less refractory than silicon carbide itself, and it is also less chemically inert. The silicon nitride bond also produces a porous, somewhat permeable refractory, though to a lesser degree than does the silicate bond.

Some *silicon-bonded* silicon carbide materials are quite dense and have high strength and excellent oxidation resistance at moderate temperatures. However, their use is limited by the 2600 F melting point of silicon.

Since the known bonding materials for silicon carbide are generally inferior to silicon carbide itself, the idea of bonding silicon carbide with itself has long been considered. For many years a type of *self-bonded* silicon carbide has been produced, but this product has relatively low strength and is quite porous.

The problem of making the dense self-bonded body is complicated by the fact that silicon carbide does not soften or melt under atmospheric conditions, but decomposes at 4000 to 4350 F. In recent years, J. R. Tinklepaugh and associates of Alfred University have produced dense self-bonded silicon carbide by hot pressing at high temperatures and pressures. Although this process results in an excellent body, it is not suitable for commercial production of large or intricately shaped pieces, and the process is comparatively costly.

During the past two years, Carborundum Co. has given considerable attention to the production of dense self-bonded silicon carbide by methods other than hot pressing. The result of this work is the self-bonded KT silicon carbide described for the first time in this article.

Flexural strength of KT silicon carbide, given in Table 2, is two to three times as great as that of commercial silicon carbide ware at room temperature. At high temperatures such as 2700 F the difference is even more marked. For comparison, flexural strength of silicate-bonded silicon carbide at 2370 F ranges from about 800 to 3000 psi.

To date, compressive strength of KT silicon carbide has been measured only at room temperature, using cylindrical test pieces about 0.4 in. in dia and 0.6 in. long. Average values range around 150,000 psi.

Modulus of elasticity of the new material is also much higher than that of silicate- or nitride-bonded wares, the difference being greater at elevated temperatures. Against values of about 40 to 70 x 10^6 psi at room temperature and 50 to 65 x 10^6 psi at 2700 F for KT silicon carbide, the modulus of silicon nitride-bonded silicon carbide ranges from about 15 to 20 x 10^6 psi at room temperature to about 3 to 10 x 10^6 at 2700 F.

Thermal conductivity appears

TABLE 2—MECHANICAL STRENGTH OF KT SILICON CARBIDE

Property / Temp / Type	77 F Coarse Grit	77 F Fine Grit	2192 F Coarse Grit	2192 F Fine Grit	2732 F Coarse Grit	2732 F Fine Grit
Flexural Strength, 10^3 psi	15	24	16	25	13	18
Modulus of Elasticity, 10^6 psi	38.8	68.5	61.4	61.5	66.7	49.4

TABLE 3—COMPARATIVE THERMAL CONDUCTIVITY OF KT SILICON CARBIDE
(Btu/sq ft/in./hr/F)

Material	752 F	1112 F	1472 F	1832 F
KT Silicon Carbide	500	400	333	293
Beryllia	612[a]	—	—	133[a]
Silicon Nitride—Bonded SiC (Niafrax 2960)	145	—	—	93
Alumina	87[a]	—	—	41[a]
Zirconia	12[a]	—	—	14[a]
Carbon Steel	316[b]	257[b]	197[b]	—
Nickel	345	377	—	—
Stainless Steel (Type 304)	139[b]	157[b]	—	—
Inconel	142	165	—	—

[a]Kingery, W. D., Coble, J. F., and Vasilos, Jr., T., *Journal of the American Ceramic Society*, vol. 37, p 107 (1954).
[b]Metals Handbook, 1948 Edition, p 314.

TABLE 5—OXIDATION RESISTANCE OF SILICON CARBIDES IN AIR
(Gain in Weight, mg/sq cm)

Exposure time, hr	KT Coarse Grit 2012 F	KT Coarse Grit 2192 F	KT Coarse Grit 2372 F	KT Coarse Grit 2552 F	KT Fine Grit, 2192 F	Nitride-Bonded SiC (Niafrax 2960), 2192 F
5	0.10	0.20	0.14	1.0	0.51	2.80
20	0.07	0.23	0.17	1.57	0.55	3.20
60	0.04	0.04	0.16	1.65	0.52	3.65

TABLE 6—STABILITY IN STEAM (2012 F) OF SILICON CARBIDES
(Gain in Weight, mg/sq cm)

Exposure time, hr	KT Silicon Carbide Coarse Grit	KT Silicon Carbide Fine Grit	Silicate-Bonded SiC (Carbofrax 978)
5	0.07	0.05	0.25
60	0.52	0.45	1.53
80	0.52	0.53	2.00

TABLE 7—RESISTANCE OF KT SILICON CARBIDE TO CORROSIVE LIQUIDS[a]

Corrosive Liquid	Weight Loss, %	Loss in Transverse Strength, %
1 Conc. HCl : 4 H_2O	None	6.5
1 Conc. HNO_3 : 4 H_2O	None	8.8
1 Conc. H_2SO_4 : 4 H_2O	None	5.9
1 Conc. HF : 4 H_2O	0.4	2.4
1 NaOH : 4 H_2O	1.5	12.4
1 Conc. HF : 4 Conc. HNO_3	2.6	28.7

[a]Test bars measured 3 x ½ x 5/16 in. and were immersed seven days at 135 F.

TABLE 4—THERMAL EXPANSION COEFFICIENTS OF KT SILICON CARBIDE

Temp Range, F	Coefficient, in./in./F x 10^{-6} Fine Grit	Coefficient, in./in./F x 10^{-6} Coarse Grit
77- 572	2.05	1.64
77-1292	2.18	2.27
77-1832	2.23	2.62
77-2192	2.17	2.80

to be higher than that of any other ceramic material at elevated temperatures. At 392 F thermal conductivity is 710 Btu/sq ft/in./hr/F. Thermal conductivity decreases with increasing temperature to 293 Btu/sq ft/in./rh/F at 1832 F. The rate of decrease becomes less as temperature increases. Table 3 compares thermal conductivity of the material with values for several ceramics and heat resistant metals.

Thermal expansion of KT silicon carbide (Table 4) is low compared with that of most ceramic materials and compared with that of heat resistant metals. The combination of high thermal conductivity and low to moderate thermal expansion should produce good thermal shock characteristics.

Abrasion resistance of both silicate- and nitride-bonded silicon carbide is outstanding, but abrasion resistance of the new material is two to four times better. An accompanying box shows comparative abrasion test samples illustrating this improvement.

KT silicon carbide is a semiconductor, specific resistivity at room temperature being about 0.1 ohm per cu cm. Though a more complete investigation of electrical properties is being made, they are believed to vary considerably with type and purity of the grain.

Stability

Silicon carbide is inert to most chemicals at room temperature and has excellent resistance to oxidation. It is readily attacked at moderate or high temperatures by some substances such as fused alkalies, iron or iron oxide, copper oxide and chlorine. Resistance of KT silicon carbide to chemical

attack at moderate or high temperatures is superior to that of granular silicon carbide.

Table 5 shows results of oxidation tests on coarse grit KT silicon carbide at several temperatures. At 2400 F or less, oxidation is relatively insignificant. At 2550 F the rate is still quite low and decreases after the first few hours due to formation of a protective silica coating.

In Table 3 it is also possible to compare oxidation resistance at 2192 F of both coarse and fine grit KT with that of nitride-bonded silicon carbide. Relative stability in steam at 2012 F of KT and silicate-bonded silicon carbide is shown in Table 6.

Resistance to several corrosive acids and alkalies was determined by measuring the loss both in weight and in transverse strength on samples which had been soaked for seven days at 135 F. Samples had an average bulk density of 3.07 gm per cu cm—representative of the present KT material but not the maximum density obtainable. Free silicon content was about 4.0%, approximately 1% higher than average. Results of the test are shown in Table 7. KT material of higher density or lower free silicon content would probably be less adversely affected by the hydrofluoric-nitric acid mixture. Silicate- or silicon nitride-bonded wares disintegrate in mixtures of hydrofluoric and nitric acids. The test produced no dimensional changes in the KT bars.

The new self-bonded silicon carbide is at present available in limited quantities for developmental testing. Inquiries should be directed to New Products Branch, Research and Development Div., Carborundum Co., Niagara Falls, N. Y.

Acknowledgment

The author is indebted to various members of the Research and Development Division of The Carborundum Co. for suggestions and help in obtaining data.

References

Kingery, W. D., Coble, J. F., and Vasilos, Jr., T., *Journal of the American Ceramic Society*, Vol. 37, p107, (1954).

Metals Handbook, 1948 Edition, p 314.

Typical parts: *1 and 4—pieces containing graphite cores; 2—ball and seat for check valve, not ground; 3 and 6—polished specimens; 5—machined piece with tip 0.060 in. o.d., 0.045 in. i.d.; 7—tube with 5/16 in. o.d., 3/16 in. i.d.*

Abrasion Resistance

Abrasion resistance was measured by both an impingement test and an abrasive slurry method.

In the impingement test, a tile-shaped 4 x 4 in. specimen was blasted with 6000 gm of silicon carbide grain at 80 psi air pressure, using a ½-in.-dia nozzle set 4¾ in. from the sample surface. Volume of material removed was taken as a measure of abrasion. Fig 1 is a sectional view comparing the KT and nitride-bonded types of silicon carbide at the point of deepest penetration.

In the abrasive slurry method, samples measuring 1 x 2 x 4½ in. were attached to a 16-in.-dia flywheel and rapidly rotated edgewise as paddle stirrers in a slurry of abrasive grain. The slurry consisted of 100 lb of water and a 50 lb mixture of silicon carbide and fused alumina, ranging in grit size from six mesh to collodial. Peripheral speed of the rotating specimens was about 2500 fpm. Abrasion was measured as volume loss. Fig. 2 shows the appearance of silicate-bonded, nitride-bonded and KT silicon carbide after a 5-hr test.

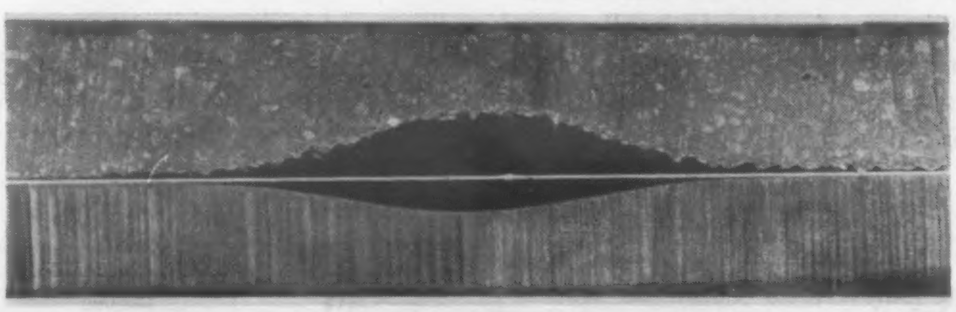


Fig 1*—Silicon nitride-bonded sample at top shows volume loss of 5.5 cu cm compared to only 2.2 cu cm for KT sample at bottom.*

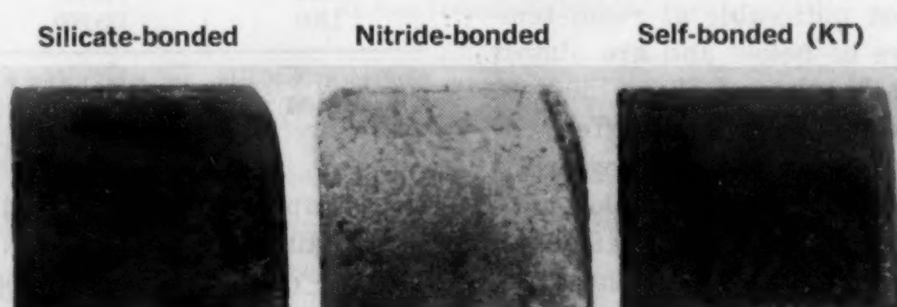


Fig 2*—After 5 hr abrasion, silicate-bonded piece shows volume loss of 2.7 cu cm, silicon nitride-bonded piece a loss of 2.5 cu cm, and KT piece a loss of only 0.7 cu cm.*

What you should know about . . .

Hydrogen in Titanium

by **D. N. Williams and R. I. Jaffee**, *Battelle Memorial Institute*

Titanium producers exert great care to minimize hydrogen pickup. This article tells why and shows you how much hydrogen you can tolerate.

■ Excessive hydrogen content in titanium can produce strain-rate sensitivity, embrittlement under shock loading and thermal instability. Fortunately, intensive research during the last few years has led to effective methods of minimizing hydrogen pick-up during production. A method of removing hydrogen from finished parts, when excessive, has also been found.

The amount of hydrogen present in titanium is measured in parts per million (ppm), one part per million equaling 0.0001% by weight. More than 20,000 ppm (2% by weight) of hydrogen is soluble in beta titanium and only a small fraction of this amount, 200 ppm (0.02%) is sufficient to cause difficulty.

Titanium can pick up hydrogen from a number of sources. The two most common are hydrogen carried into the melting furnace in the sponge and that introduced into the metal during descaling and acid pickling. These sources of contamination are now minimized by proper control in all stages of the melting, fabricating and descaling operations. In addition maximum hydrogen tolerances of 150 ppm for sheet and 125 ppm for forgings have been set for aircraft components. Use of adequate stress-relieving treatments following forming and care in assembly to prevent assembly stresses also minimize failures caused by hydrogen. Moreover, hydrogen can be removed from a finished part by vacuum annealing above 1200 F.

1. It induces strain-rate sensitivity

One of the most serious effects of hydrogen in titanium alloys is its ability to promote marked strain-rate sensitivity. As little as 200 ppm of hydrogen in certain alpha-beta titanium alloys is sufficient to cause the alloy to become extremely brittle under slow strain conditions such as occur during creep. Rapidly strained material shows no evidence of embrittlement. Strain-rate effects are most noticeable at room temperature or below and are almost completely absent above 300 F.

Table 1 shows the effect of hydrogen on the tensile properties of a typical alpha-beta alloy. Although little effect is noticed up to 180 ppm, 270 ppm reduces the ductility drastically.

TABLE 1—EFFECT OF HYDROGEN ON SLOW-SPEED TENSILE PROPERTIES OF STABILIZED 8% MANGANESE TITANIUM ALLOY[a]

Hydrogen Content, ppm	Ten Str, psi	Yld Str, psi[b]	Elong, % in 4D	Red in Area, %
15	142,000	141,000	31	55
66	144,000	143,000	33	58
180	147,000	147,000	36	61
270	146,000	146,000	10	7
600	148,000	148,000	6	4
1200	155,000	155,000	4	0

[a]Tested at 0.005 in. per min, using a standard 0.25 in. gage length round tensile specimen.
[b]Upper yield point.

Under room-temperature creep conditions, the effect is more pronounced. An alloy that will withstand stresses as high as 170,000 psi almost indefinitely in a notched stress-rupture test, may fail in a brittle manner in a few hours at stresses of less than 100,000 psi when 250 ppm of hydrogen is present.

Since designers normally do not allow working stresses above the elastic limit, it might be assumed that strain-rate sensitivity would not be a problem in many applications. However, this is not the case. Residual stresses present in a formed part are often sufficient to induce embrittlement, or delayed cracking. Stresses introduced during assembly may also cause subsequent cracking.

Although considerable research

has been devoted to the problem of strain-rate sensitivity, a completely satisfactory explanation has not been developed. The evidence indicates that it results from a strain-induced precipitation of hydride along the alpha-beta interface. Some alloys are more prone to strain-rate sensitivity than others, and the hydrogen tolerances of commercial alloys are being determined.

Fortunately, strain-rate sensitivity is confined chiefly to alpha-beta alloys. Alpha alloys are subject to this defect only if sufficient impurities are present to promote the retention of appreciable beta. Beta alloys show strain-rate sensitivity only when large amounts of hydrogen are present.

2. It causes lower notch toughness

Unlike hydrogen in steel, where gaseous hydrogen is present once the solubility limit is exceeded, a hydride is formed in the titanium-hydrogen system. Although the solubility of hydrogen in beta titanium is quite high, the solubility in alpha titanium decreases rapidly with temperature, and at room temperature less than 50 ppm of hydrogen is soluble. Hydrogen in excess of this amount precipitates as fine hydride particles. Table 2 shows that hydride particles have a marked effect on notch-toughness properties but not on the ordinary tensile properties.

The detrimental effects of hydrogen in alpha titanium can be reduced somewhat by heat treatments designed to control the mode of hydride precipitation. Alloys quenched to room temperature from 500 F or above have a fine dispersion of titanium hydride precipitated. These are much less notch sensitive than alloys cooled slowly to room temperature, where the hydride forms large plates. Alloying is also effective in reducing impact embrittlement due to hydrogen.

The two principal methods used to minimize hydride formation in alpha alloys are 1) addition of small amounts of beta-stabilizing elements to form areas of beta "getters" and 2) alloying with aluminum, which apparently increases the solubility of hydrogen in alpha titanium appreciably.

TABLE 2—EFFECT OF HYDROGEN ON PROPERTIES OF COMMERCIALLY PURE TITANIUM

Hydrogen, Content, ppm	Ten Str, psi	Red in Area, %	Notch Bend Impact Strength[a], in.-lb.			
			−320 F	−40 F	77 F	212 F
10	68,000	55	39	38	36	39
50	70,000	64	17	21	24	33
200	67,000	54	5	6	11	21
480	69,000	50	1	1	1	3

[a]Impact values obtained on a micro impact specimen. Numerical values in in.-lb are roughly equivalent to those obtained with the Charpy specimen in ft-lb.

3. It increases thermal instability

Hydrogen increases the instability of alpha-beta alloys in elevated-temperature service. Although most alpha-beta alloys are basically in a nonequilibrium condition below about 1100 F, the rate of precipitation of alpha from the unstable beta is sufficiently sluggish to permit extended service in the temperature range 800 to 1000 F. However, the presence of small amounts of hydrogen apparently increases the transformation rate considerably. This is illustrated in Table 3. Stability, measured by the effect of prolonged elevated-temperature exposure on subsequent tensile ductility at room temperature, is drastically reduced by the presence of hydrogen.

TABLE 3—EFFECT OF HYDROGEN ON THERMAL STABILITY OF TI-140 A (Ti-2Mo-2Cr-2Fe)

Hydrogen Content, ppm	Ten Str, psi	Yld Str, 0.2% Offset, psi	Elong, % in 4D	Red in Area, %
	As Heat Treated (Stabilization Heat Treatment)			
40	135,000	123,000	23	26
360	137,000	128,000	23	25
	After 200 Hr at 600 F. Stressed at 50,000 Psi			
40	137,000	126,000	19	13
360	144,000	—	0	2
	After 200 Hr at 800 F. Unstressed			
40	144,000	126,000	12	13
360	72,000	—	0	0

Note: Tests made at room temperature.

Economical application *is an important feature of the new sealant. It can be applied individually to assembled fasteners, as shown here, or, since the sealant will not harden in air, it can be applied to small fasteners in large quantities by tumbling.*

New Sealant Locks Threaded Fasteners

This unique polymer, a free-flowing liquid until it gets between the nut and the threaded shank, provides a much higher break-loose torque than can be obtained with most locknuts.

■ A liquid polymer with the physical appearance of kerosene hardens automatically in joints between closely fitting metal parts to form strong, heat and oil resistant seals. When applied to the threads of a common fastener, the material forms a tough seal that prevents the fastener from being shaken loose by vibration. The seal provides a break-loose torque higher than the initial run-in torque, yet sealed fasteners can be removed with ordinary tools and reused.

Called Loctite, the one-component sealant can also be used to bond metal sleeve joints and to seal porous welds and leaky threads in pipelines. The sealant can be used with almost any commercial metal. Cadmium or zinc surfaces require treatment with a special activator before the sealant is applied.

Loctite can be applied either to individual fasteners or to batch quantities in tumbling barrels. It is a nonvolatile thermosetting material which remains a low viscosity fluid as long as it is stabilized by exposure to air. Cure is effected by the catalytic action of metal surfaces and the exclusion of oxygen. Because of this curing phenomenon, a nut can be locked at any position on the threaded length. Developed by American Sealants Co., of Hartford, Conn., Loctite is said to provide higher break-loose and prevailing torques than common mechanical locking devices such as locknuts.

The material is available in three grades: A, C and D. A and C have the same viscosity characteristics but provide different holding torques. Grade D is a higher viscosity fluid.

Cured properties

Curing of Loctite starts in a few hours and is complete in a few days. Break-loose torques of 65% of the final value are reached in 12 hr, and 85% in 24 hr, except in the case of grade C which requires 24 to 48 hr. Cure can be accelerated by use of heat.

Loctite sealants are intended for use under shear rather than tensile stresses. Shear strength of

Loctite A and D is designed to be 750 to 1000 psi in order to produce locking torques appropriate to the torsional strength of steel bolts. Loctite C, with a moderate shear strength of 150 to 250 psi, is designed for use with the softer metals such as aluminum and copper, where fasteners may have to be taken apart for repair work, or where screws must be readily adjustable.

The holding action of the sealant when the nut is unfastened with a torque wrench resembles the action of a combination of a multiple-tooth lock washer and a prevailing-torque type locknut. The high initial break-loose torque due to the bond is followed by a high prevailing torque due to frictional drag of the plastic which persists for several turns.

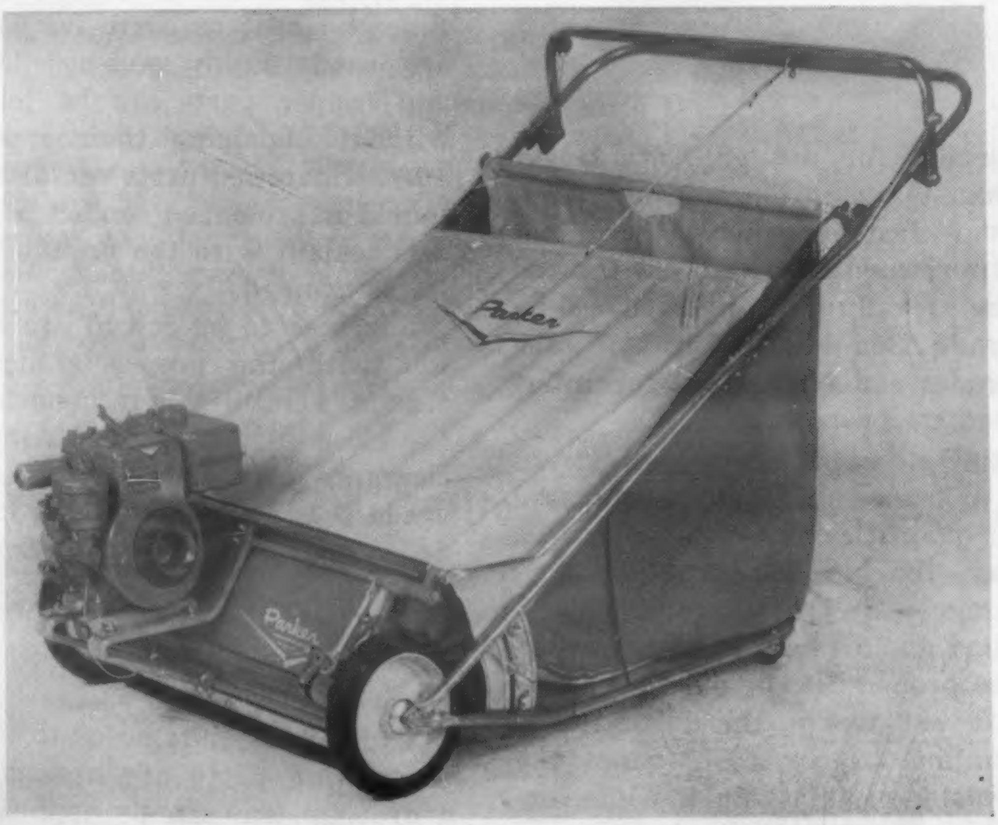
Resistance of sealed fasteners to heat aging is adequate for most machine applications. Serious loss of prevailing torque in steel fasteners generally does not occur during exposures of up to 1000 hr at temperatures up to 300 F. Resistance to thermal shock seems adequate for most applications. Sealed fasteners have withstood repeated cycling from 350 to —65 F.

Resistance of the cured sealant to chemical attack is characteristic of thermosetting plastics. Oil, common solvents and water do not affect the material, and mineral acids and alkalies attack it slowly.

Individual application

For large fasteners, such as 3/8 x 1½ in. or larger, the sealant can be applied economically by placing a drop on each screw thread where it enters the mating part. The thin liquid is drawn into the joint by capillary action much like penetrating oil. One 10 cc bottle will treat 500 standard full ¼ x 28

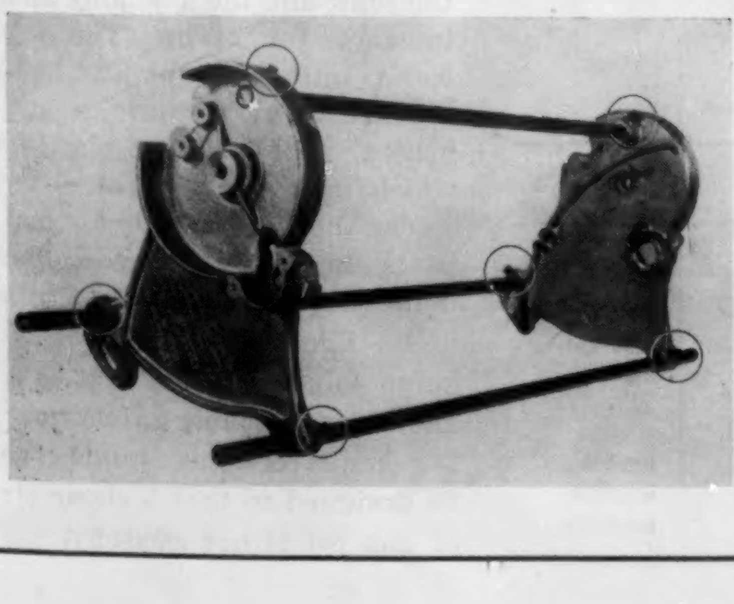
Fastener Sealant Improves Power Sweeper

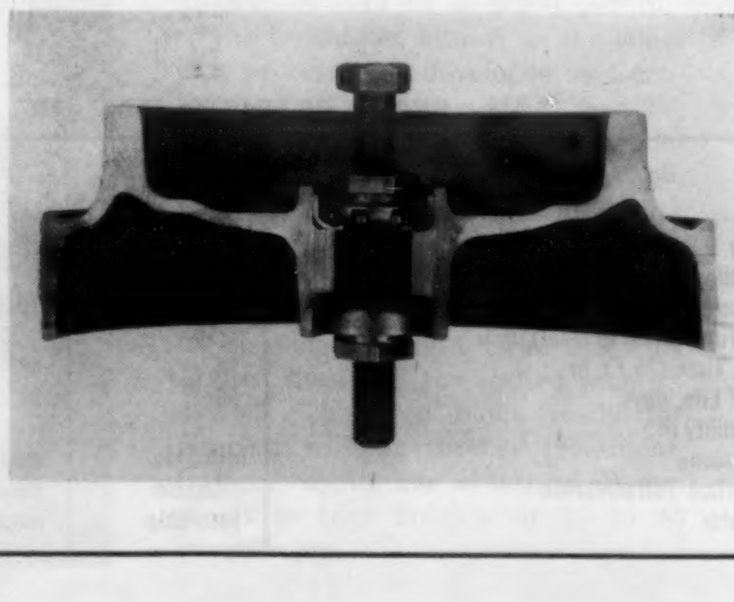


Improved operation and simplified manufacture resulted from use of the new sealant on two different subassemblies in this power sweeper:

1. The four setscrews (circled) on the base assembly (below, left) are now locked with the sealant. Previously, these setscrews would loosen during operation, throwing the shaft out of line and thereby wrecking the gear train that transmits power from the motor to the wheels.

2. Loctite is also used to hold the bearing cup in the cast iron wheel (below, right). Cup and wheel were previously press fit, requiring extreme accuracy in forming the hole in the wheel, as well as care in forming and hardening the cup. Use of the sealant prevents the cup from breaking away from the wheel during operation, and permits allowance of an extra 0.002 in. on the hole size, simplifying manufacture.





LOCKING TORQUES—LOCTITE SEALANT VS MECHANICAL LOCKING DEVICES[a]

Screw size	Tightening Torque, in.-lb	Break-Loose Torques, in.-lb							Prevailing Torques, in.-lb						
		Loctite		Locknuts				Spring-lock washer, in.-lb	Loctite		Locknuts				Spring-lock washer
		A or D	C	A	B	C	D[b,c]		A or D	C	A	B	C[d]	D[c]	
2-64	2	2.5	2.0	—	—	—	—	—	2.0	1.0	—	—	—	—	—
2-56	1.5	2.1	1.5	—	—	—	—	—	1.5	1.0	—	—	—	—	—
5-44	7	8	5	—	—	—	—	—	6.0	2.0	—	—	—	—	—
5-40	6	6	4.5	—	—	—	—	—	4.5	2.0	—	—	—	—	—
8-36	15	18	12	—	—	—	—	—	14	6	—	—	—	—	—
8-32	12	15	11	—	—	—	—	—	11	5	—	—	4-12	—	—
1/4-28	48	70	50	35	38	—	5-6	33	60	25	10	9	10-25	30-40	0
1/4-20	42	50	50	30	32	—	5-6	25	50	25	—	—	10-25	30-40	0
3/8-24	190	240	200	150	145	—	12-16	125	180	70	23	35	25-55	80-107	0
2/8-16	170	200	180	140	140	—	12-16	110	140	60	—	—	25-55	80-107	0
1/2-20	450	500	450	400	410	—	22-30	380	400	130	65	60	50-100	150-200	0
1/2-13	370	480	450	350	340	—	22-30	265	300	120	—	—	50-100	150-200	0

[a] Locktite values based on individual application to degreased machine screw and nut assemblies after tightening to the specific torque, which provides a bolt stress of about 33,000 psi. Cure time 48 hr at room temperatures. Torque values given are averages. Individual readings usually fall within ±30% of the average.
[b] No load on bolt.
[c] Industrial Fastener Institute specifications.
[d] Manufacturer's specifications.

bolts. Sealant may be applied either before or after the fastener is tightened to proper torque. Because there is no additional frictional drag during tightening, torque can be easily related to bolt stress.

Grade A is used for fine threads. For fasteners with coarse threads and a loose fit, excessive drainage can be eliminated by using the more viscous grade D. Intermediate viscosities can be obtained by blending the two formulations. For fasteners that must remain readily adjustable in use, grade C, with moderate holding power, is used. This grade is also recommended for use on bolts larger than ½ in. in dia, and on aluminum fasteners which are not strong enough to safely withstand the prevailing torque produced by grade A on disassembly. All three grades can be blended for intermediate properties.

Multiple application

When small fasteners are used in quantities of at least 1000 a day, the sealant can be applied economically by tumbling. Tumbling applies a uniform coating of the proper thickness over the entire surface of the fasteners at minimum labor cost. Since the sealant remains fluid while exposed to air, coated fasteners can be used on hand assembly lines about as easily as untreated fasteners.

Treated steel fasteners can be stored a day or two before use. Treated brass fasteners should be used within 8 hr. For best results, fasteners should be degreased before treating with Loctite. Quantity of sealant to be used in tumbling depends on the surface area of the fasteners to be treated. One 10 cc bottle of Loctite A covers from 500 to 1500 sq in. of fastener area.

Bonding joints

Loctite sealant can be used to bond metal joints, provided the joint is to be stressed in shear. It is claimed to be ideal for sleeve joints, taper joints, threaded couplings for rods and tubes, and crimped seams in sheet metal. Since no heat or corrosive fluxes are used, highly polished brass and copper parts can be joined without impairing their appearance. Enameled parts can also be joined if prolonged contact of excess sealant with the organic finish is avoided.

Surfaces to be joined are first wet with the proper grade of sealant. Loctite A is recommended for close fitting joints having a clearance of 2 mils or less, and grade D is recommended for loose fitting joints having a clearance of 2 mils or more. One 10 cc bottle of A or C grade covers 500 to 1500 sq in., and a 10 cc bottle of D covers 250 to 750 sq in.

To bond sleeve-type joints after the mating parts are assembled, a drop or two can be applied to the joint and the assembly allowed to stand for 24 hr. The sealant works into the joint and hardens automatically, forming a strong, heat and oil resistant plastic seal which is pressure tight.

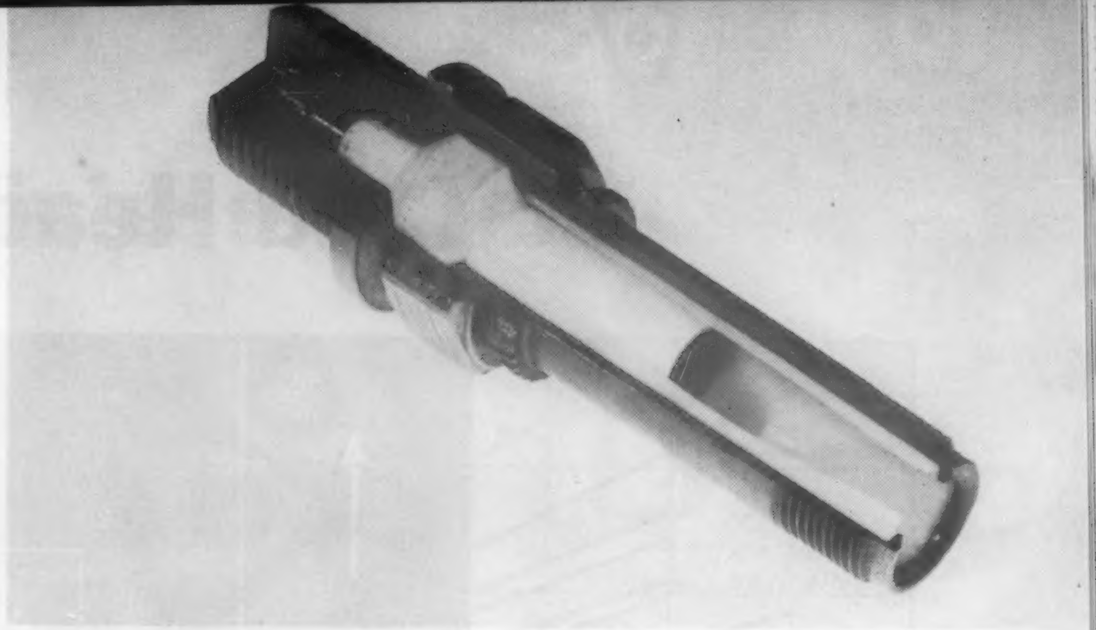
The better the fit of mating parts the better the seal. Maximum clearance should be 5 mils or less. Shear strength of fully cured joints is about 750 psi. To allow a reasonable safety margin for imperfections, joints should be designed so that a shear stress of 200 psi is not exceeded.

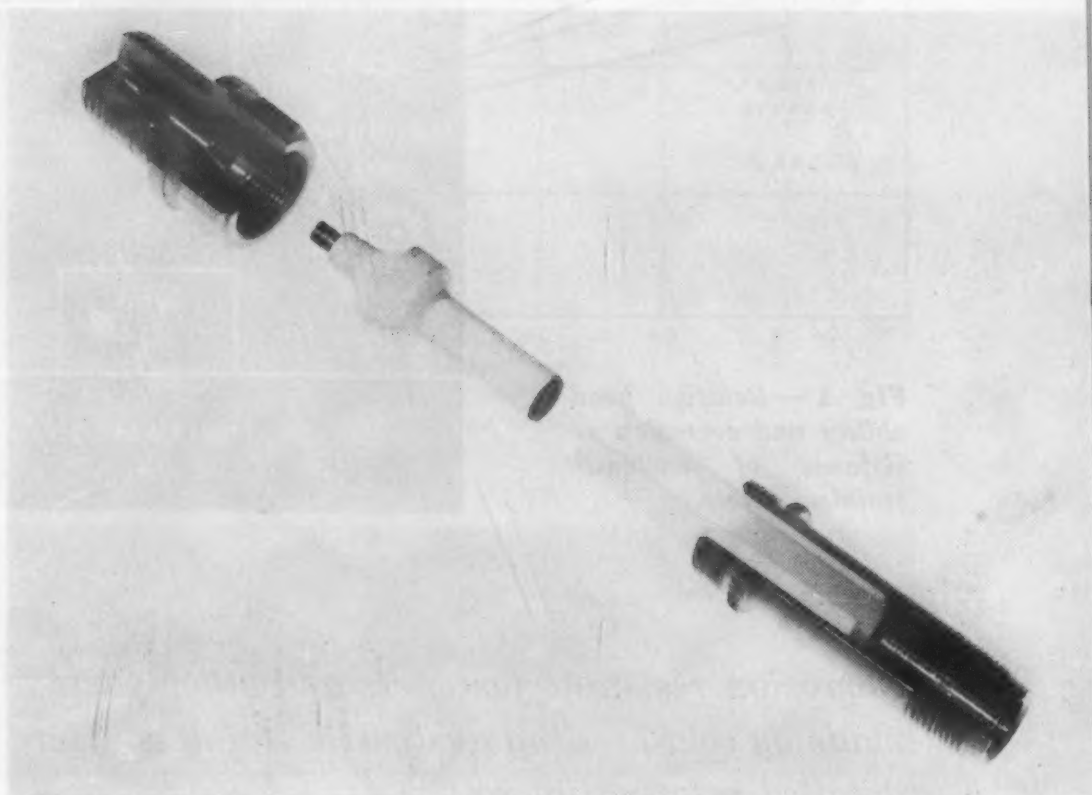
GRADES OF LOCTITE SEALANTS

Property	Grade A	Grade C	Grade D
Color	Red	Blue	Orange
Volatiles, %	<1	<1	<1
Viscosity, cps	10-15	10-15	40-50
Set Time (steel to steel), min	<10	<10	<10
Cure Time (75 F), hr	24	48	24
Shelf Life, days	90	90	90
Solubility in:			
Acetone	miscible	miscible	limited
Carbon Tetrachloride	miscible	miscible	miscible
Water	insoluble	insoluble	insoluble

MATERIALS AT WORK

Teflon replaces ceramic as spark plug liner





Liners used in the spark plugs made by Jet Ignition Co. must maintain a good seal and have high dielectric strength. These liners were customarily made of a ceramic until it was found that use of Teflon plastic, despite its high initial cost, could provide several advantages:

1) Unlike ceramic liners, the plastics liners need no gaskets at the ends to prevent breakage (see exploded view).

2) Tolerance of ± 0.005 in. can be held on both i.d. and o.d., compared to ± 0.010 in. on o.d. and + 0.010 to — 0.000 in. on i.d. for the ceramic.

3) Unlike ceramic liners, which are fragile and easily broken on fitting and handling, Teflon liners are flexible and resilient. They do not fracture and they bend or stretch to compensate for misalignment in plug assembly.

The Teflon liner consists of thin walled tube made by Raybestos-Manhattan and cut to length.

Silica glass molds for precise metal parts

A silica glass powder is used to make investment molds for steel and aluminum parts. The low thermal expansion of the material assures tight dimensional control. The molds, consisting of 96% silica glass powder, can withstand metal pouring temperatures up to 3300 F with tolerances held to ± 0.005 per in.

The technique, known as the Glascast process, was developed by Corning Glass Works (see M&M, Sep '55, p 12). The wax pattern, shown in the extreme left of the photograph, is dipped in a slurry and coated with grains of the silica glass. After the pattern is dried and coated several times, a mold is built up as shown at the extreme right. The assembly is then fired and the melted wax removed. The fired mold, ready for pouring without further treatment, is lightweight, has a thin shell and yields surface finishes of 20 to 40 microinches.

Cold Headed Parts from

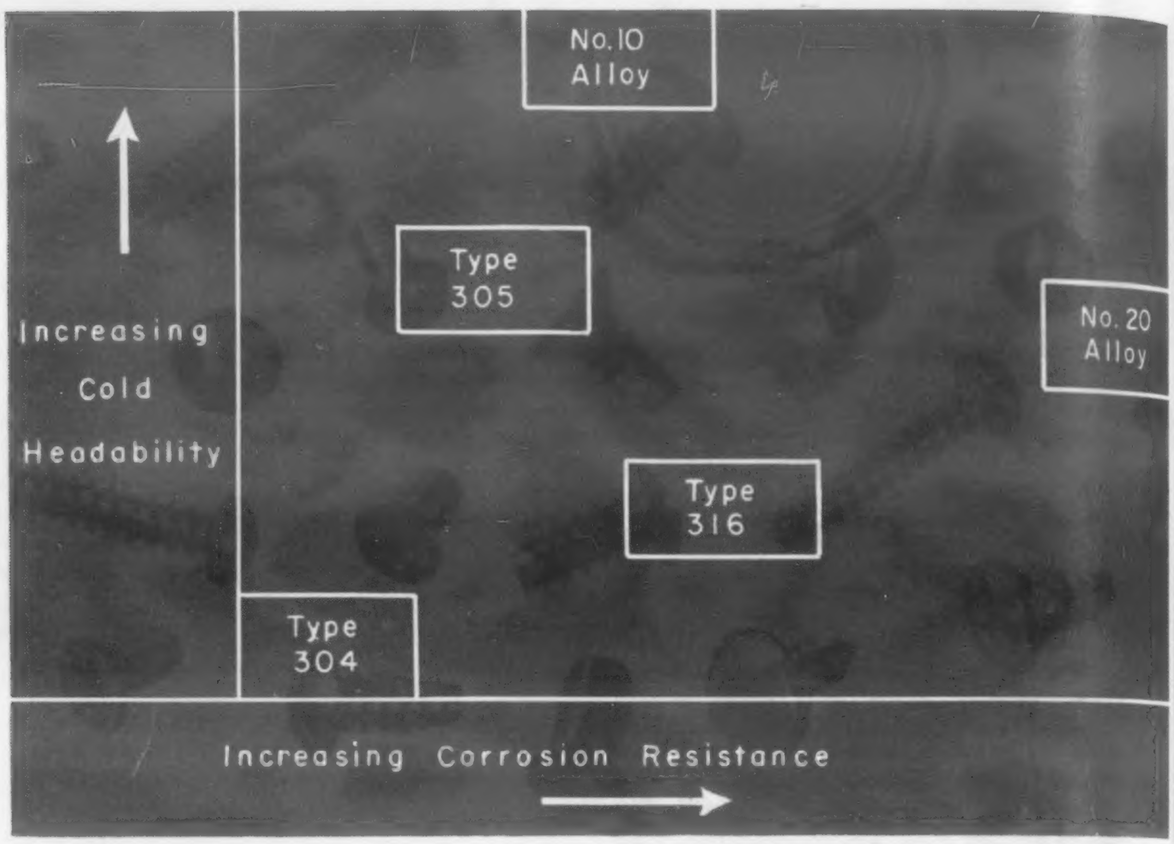


Fig 1*—Relative headability and corrosion resistance of austenitic stainless steels.*

Corrosion resistant fasteners and other parts are made by cold heading austenitic stainless. Here is detailed information on:

- *How to select the proper grade of stainless*
- *What you must know about wire quality*
- *What you must know about effects of head design*

by S. E. Tyson, *Carpenter Steel Co.*

■ When manufacturing cold headed parts from stainless steel for applications requiring superior corrosion resistance, it is necessary to choose from the austenitic grades. Some of them are covered by the conventional AISI numbers and some are too recent to be included in the AISI group. Cold heading such chromium-nickel stainless steels involves problems not usually encountered when using the more easily formed steels.

Choice of the proper grade of austenitic stainless steel for cold headed parts must be based upon corrosion resistance and cold headability. Fig 1 is a schematic diagram showing the relative headability and corrosion resistance of the popular cold heading austenitic grades. The analyses of these grades are given in an accompanying table.

Stabilized grades of austenitic stainless steels, AISI Types 321 and 347, are not included because these grades are used chiefly for applications involving welding. However, the stabilized grades should not be overlooked if the headed part is to be subjected to temperatures over 800 F. Also not listed are the alloys which exhibit high temperature oxidation resistance and strength, such as AISI Types 309, 310 and the superalloys.

Corrosion resistance

Stainless Types 304 and 305 have approximately the same corrosion resistance. They resist atmospheric corrosion as well as foodstuffs, nitric acid, most organic chemicals, and many inorganic chemicals. Type 316, with superior corrosion resistance, resists corrosive environments, such as phosphoric and acetic acids. It is used considerably by the chemical processing industries. The No. 10 alloy is somewhat superior to Type 304, since it has corrosion resistance comparable to Type 316 under certain conditions. The most corrosion resistant stainless grade is Carpenter No. 20. It exhibits good resistance to hot sulfuric, phosphoric, nitric and all the organic acids.

Cold headability

For successful cold heading, the steel selected must withstand the heading operations without rup-

Austenitic Stainless Steels

ture, and the tools must not wear prematurely, crack or chip. Type 304 is suitable only for the least severe cold heading operations. Its resistance to cold working, from the standpoint of tool life alone, makes severe cold forming operations impractical.

Type 305 is the choice for many headed parts including those produced by two stage heading procedures as well as other severely upset shapes. Type 316 and Carpenter No. 20 compare favorably with Type 305 in headability. Carpenter No. 10 is the first austenitic stainless grade engineered specifically for making recessed head screws, the manufacture of which once involved excessive tooling costs.

Work-hardening rates of austenitic stainless steels are an indication of their relative cold headability. Those showing the least increase in hardening per given degree of cold work will require less work to form and cause less tool wear. Fig 2 shows the approximate increase in tensile strength with cold work. (Cold work is measured in terms of reduction in area by wire drawing.) AISI Types 301 and 302 and a general curve for the ferritic stainless grades are included for comparison. Type 305 has a much lower work-hardening curve than Types 304 and 316. The No. 10 alloy with an even lower work-hardening rate, is only slightly above the ferritic grades such as Type 430.

The work-hardening characteristics of these alloys are dependent on composition. The most important single element is nickel. As nickel content increases, the austenitic structure becomes more stable. The higher nickel grades have less tendency to become magnetic with increasing amounts of cold work.

The increase in magnetism is an indication of the amount of pseudo-martensite (a micro constituent of austenitic stainless steels which increases the hardness) which will form during cold working. By making the austenitic grades more stable, the increase in hardness due to the formation of pseudo-martensite is eliminated and the over-all work-hardening rate is decreased. For example, Type 305 and the No. 10 alloy are increasingly more stable than Type 304. No. 10 alloy does not become magnetic and therefore work-hardens the least, en-

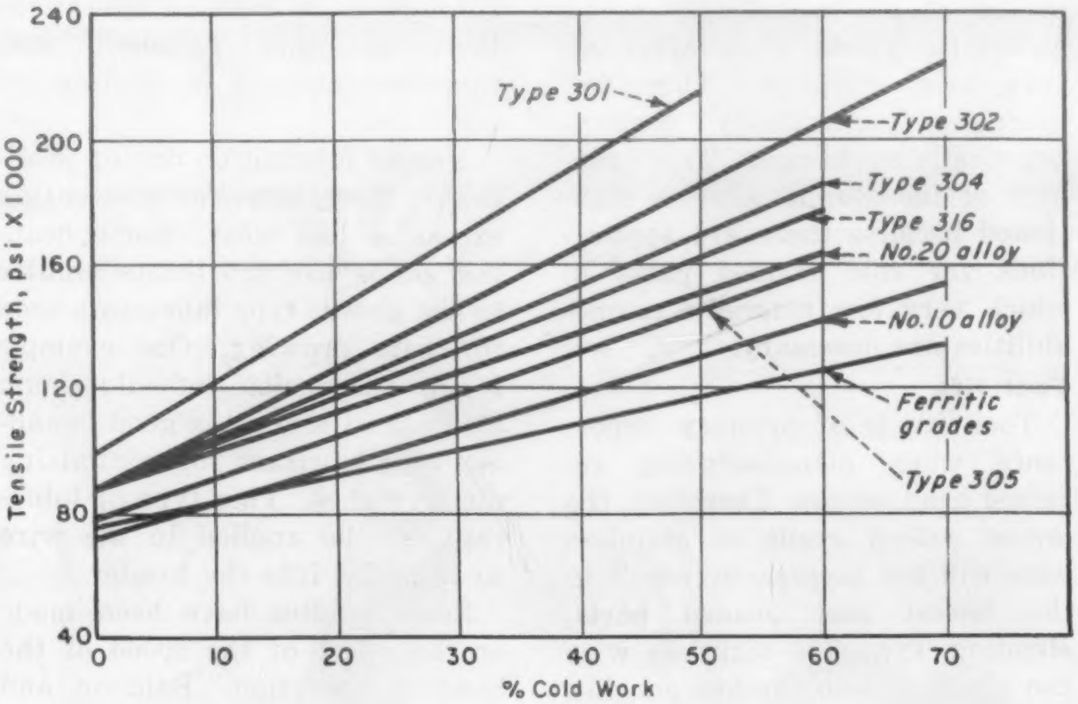


Fig 2—Work hardening of austenitic stainless steels.

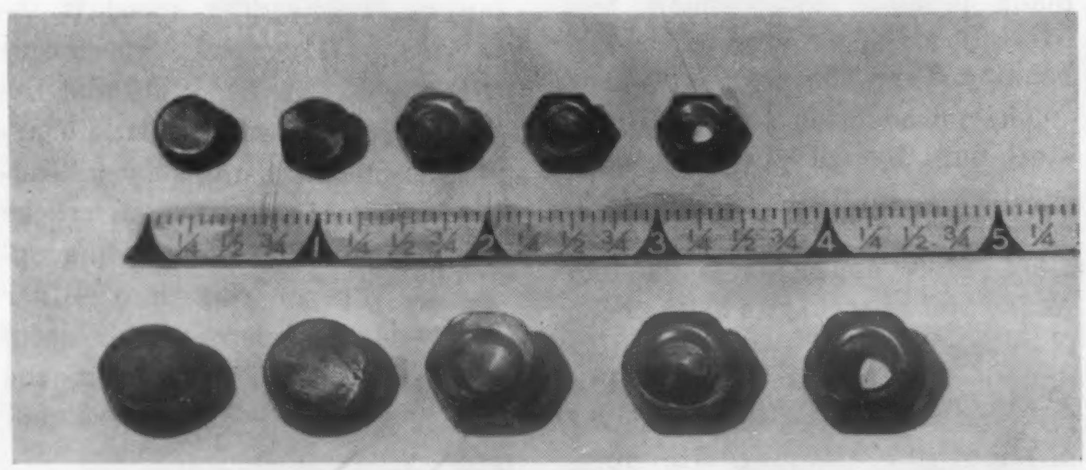


Fig 3—Progressive stages in heading standard nuts of No. 10 stainless.

NOMINAL COMPOSITION (%) OF COLD HEADING AUSTENITIC STAINLESS STEELS

	C Max	Mn Max	P Max	S Max	Si Max	Cr	Ni	Mo	Co
AISI Type 304	.08	2.00	.045	.030	1.00	18.00/20.00	8.00/11.00	—	—
AISI Type 305	.12	2.00	.045	.030	1.00	17.00/19.00	10.00/13.00	—	—
AISI Type 316	.08	2.00	.045	.030	1.00	16.00/18.00	10.00/14.00	2.00/3.00	—
Carpenter No. 10	.08	2.00	.045	.030	1.00	15.00/17.00	17.00/19.00	—	—
Carpenter No. 20	.08	2.00	.045	.030	1.00	19.00/21.00	24.00/30.00	2.00/3.00	3.00/4.00

abling a reduction of tool wear and punch breakage.

The higher nickel content in the No. 10 alloy (18% nickel) makes it an exceedingly stable austenitic grade, even after severe cold working. Therefore, magnetic permeability remains practically unchanged. This property of the No. 10 alloy is mentioned because there are applications for cold formed parts in which very low magnetic permeabilities are necessary.

Tool life

Tool life is of primary importance when manufacturing recessed head screws. Therefore, the lowest priced grade of stainless wire will not necessarily result in the lowest cost headed parts. Heading Type 304 stainless wire can result in many broken punches and excessive machine down time. Although Type 305 offers much improvement, No. 10 alloy has made possible 25% longer tool life than that obtained when heading Type 305.

The production of stainless steel nuts by cold heading, once considered impractical, has been accomplished by using the No. 10 alloy. Here again, excessive tool wear and breakage have been eliminated by the lower work-hardening rate of the alloy. Fig 3 shows the progressive steps of heading two different size nuts. An adherent copper coating is particularly important to the successful cold heading of stainless nuts such as these. They proceed through more heading operations than do other fasteners and, therefore, chances for galling are increased.

Proper lubrication during heading is necessary for preventing excessive tool wear. Some heading shops use lubricants similar to the grease type lubricants used for wire drawing. One example is a suspension of aluminum stearate in lard oil, a good boundary type lubricant for minimizing die scratches. This type of lubricant can be applied to the wire as it is fed into the header.

Some studies have been made on the effect of the speed of the heading operation. Baldwin and Beiser have indicated that austenitic stainless steels have an increasing tendency towards cracking as the heading speed is increased. However, experiences with steels like Type 305 and the No. 10 alloy shows that little benefit is gained by using slower heading speeds if compression cracks form during the cold heading operation. Proper control of other factors usually permits successful heading of these steels at the operating speeds of present machinery.

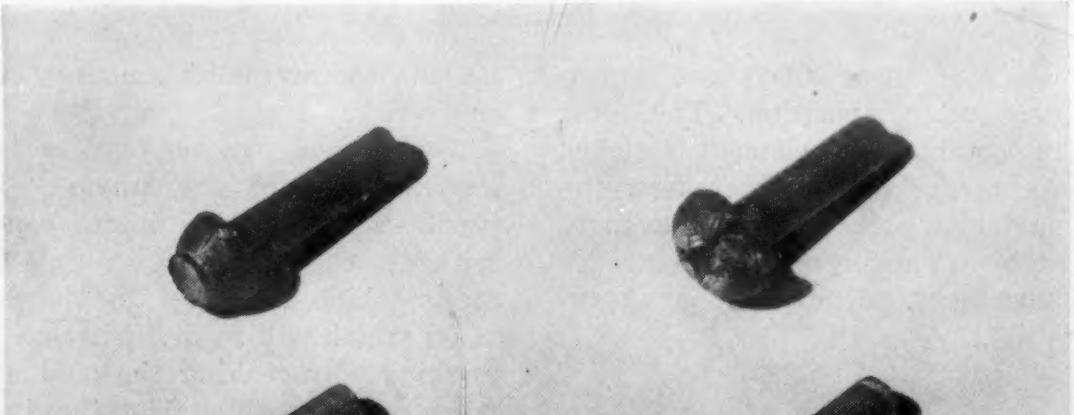


***Fig 4**—Split heads caused by excessive seams in wire. Left—first stage. Right—finished head. Top parts still coated; bottom parts have had coating stripped.*

Wire quality

The best cold heading wire, regardless of the analysis, is wire with the lowest possible hardness and a certain amount of stiffness so that it can be fed smoothly into a cold heading machine. This wire is produced by annealing it to a dead soft condition when it is at a size slightly larger than the finished wire, then coating it with copper plate and a lubricant (such as lime and soap or aluminum stearate) and cold drawing to the finished size. The principal requirement of the copper coating is good adherence.

The light final draft produces a coil which contains neither bends, kinks nor twisted strands which could cause jamming while the wire is being fed into the heading machine. Lightly drafted wire also has better shearing properties than dead soft material which tends to flatten on shearing. In contrast, wire which has been annealed after final drawing to size will not feed to the heading machine as well as the cold drawn coil.

It is generally recognized that the seam depth of austenitic stainless heading wire should be limited to approximately 0.002 to 0.003 in. on the popular sizes. Experience has shown that stainless wire can be successfully cold headed even to recessed heads of truss head design if the seam depth is held within this range.

Excessive seams in the wire will cause split heads in the finished parts. Fig 4, illustrating both stages in the heading of a recessed head austenitic stainless steel, shows how an excessive seam opens causing a split head. This defect can be recognized best by first removing all coatings from the headed part. The seam can be traced along the wire up through the split. The direction of the split is parallel to the axis of the wire.

Scratched or galled headed parts can result from poorly coated wire or improper tooling. If scratching always occurs at the same spot on the finished part, the

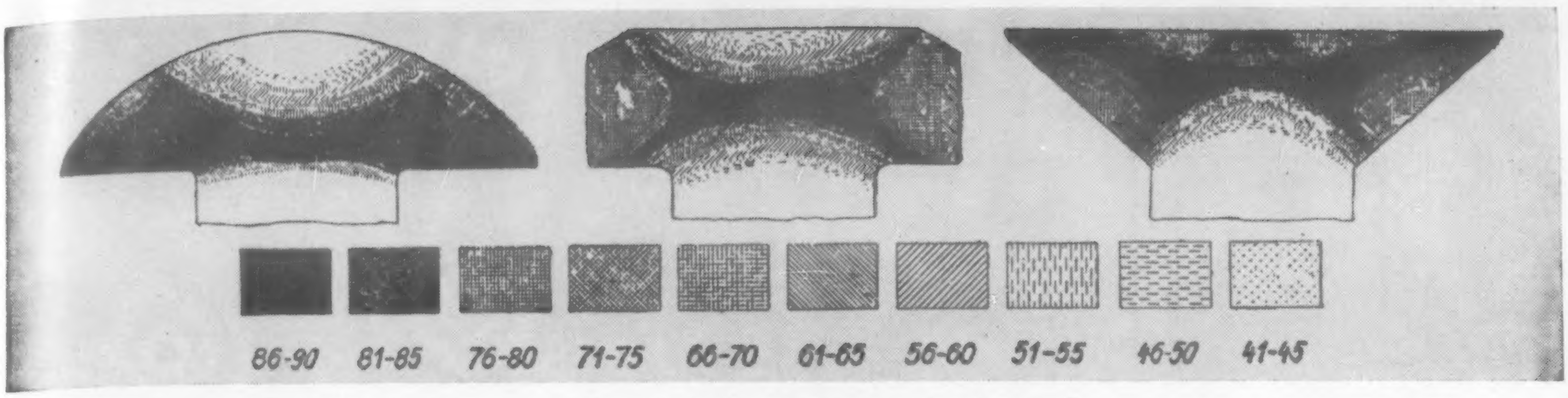


Fig 5—*Strain patterns in cold heading. Figures indicate degree of cold work.*

tooling should be investigated. It is also possible that wire, as received from the producer, may contain superficial scratches from the wire drawing dies. Usually only 0.001 in. deep, scratches from wire drawing seldom affect the cold headed product. In contrast to a seam, a wire drawing scratch can be seen without removing the surface coatings. It is a narrow, shallow trough rather than a tight, sharp defect appearing as a line.

The method of packaging coils of cold heading wire is usually specified by the consumer. Generally, coils are wrapped in waterproof paper and are shipped loose or in bundles. Careful handling and bracing for shipment are necessary if kinked strands of wire are to be avoided. Nicked and kinked wire is always a possible source of trouble for the heading machine operator.

If poor quality wire is suspected, proof can best be obtained by showing that the wire will make defective heads while similar wire can be successfully headed on the same machine setup. The consumer of stainless heading wire aids himself considerably when he assists the wire producer to establish deficiencies which cause poor headability. The wire manufacturer must rely on service reports from his customer in order to upgrade wire quality and correct specific conditions. Only by freely exchanging information and ideas can the producer satisfy the needs of the consumer.

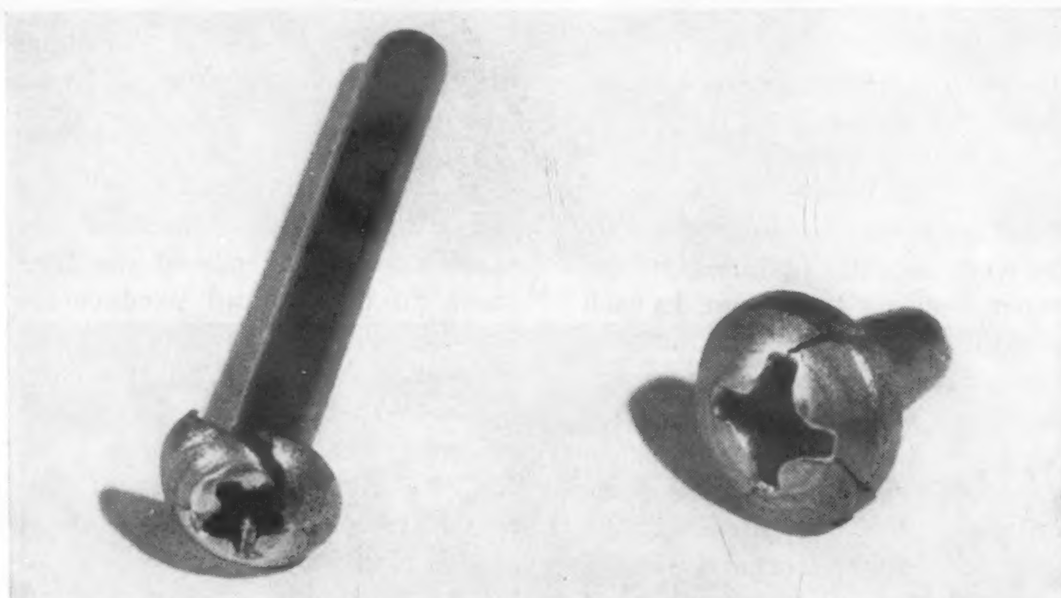


Fig 6—*Stress cracks in finished heads.*

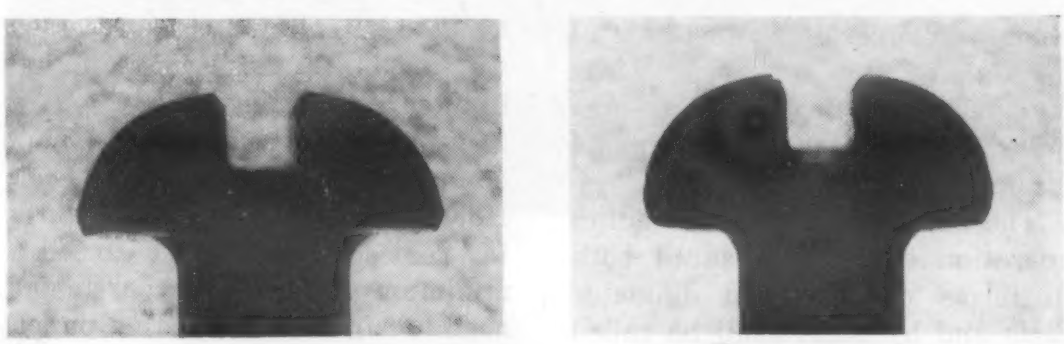


Fig 7—*Effect of minor design changes on the headability of fasteners. Left: stress cracks formed during heading—note sharp corners. Right: headed successfully—note rounded corners.*

Effects of head design

It may not be possible to change head design but it is in order to point out some of the difficulties encountered in making various designs. Wistreich has given an excellent discussion of the influence of head design upon cold headability. Fig 5 illustrates strain patterns arising from the cold heading of several basic designs. The degree of local deformation of the cold worked metal depends on the shape of the headed part. Round heads are more subject to stress cracks than are other head shapes.

Stress cracks may arise also from poor heading practice. See Fig 6. The heading operator should check his dies to ascertain that they are properly aligned to eliminate the possibility of forming eccentric heads. An off-center head formed during the first stage may cause excessive stresses in some portion of the head during the final blow. Many cases in

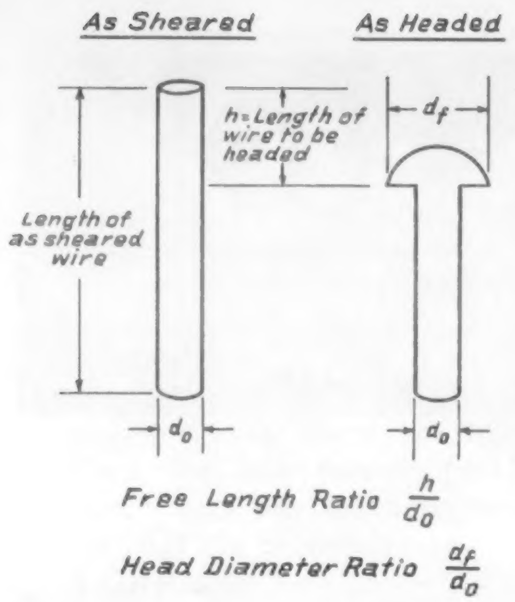


Fig 8—*Headability parameters for design of fasteners.*

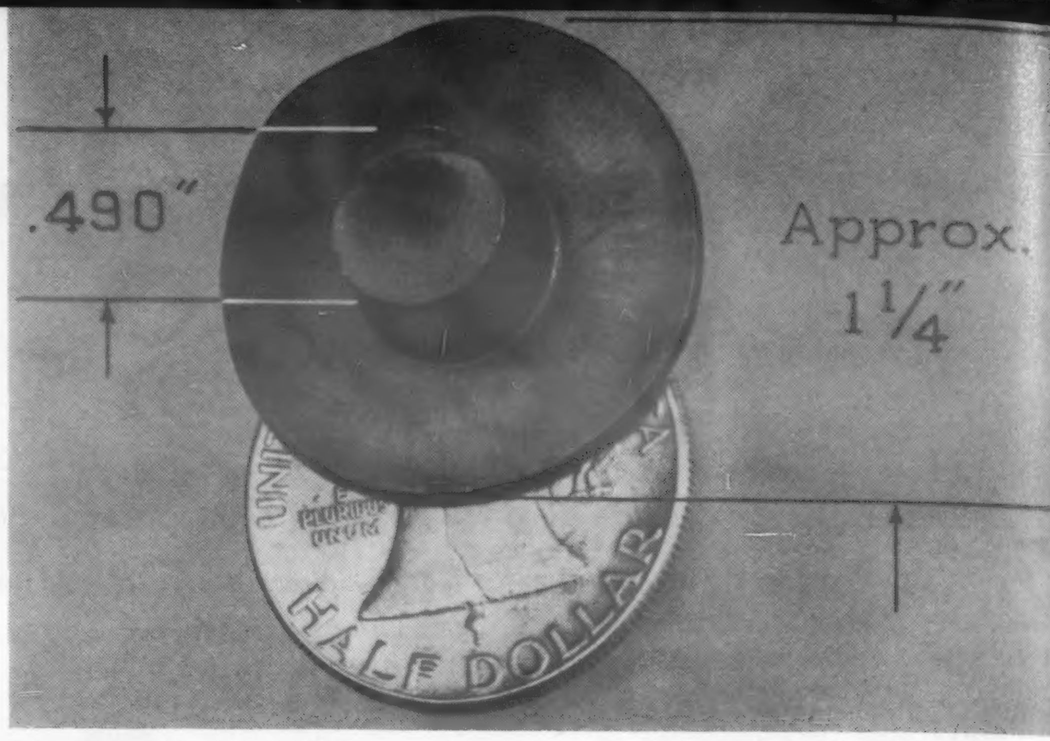


Fig 9—*Cold headability of No. 10 alloy is indicated by the spread in 0.490-in. wire.*

which wire was considered defective were actually instances of improper heading technique. In each case, the wire was headed successfully after adjustments were made.

Some critical heads can be fabricated successfully if stresses are minimized by not forming the metal into sharp corners. Fig 7 shows a particular slotted head screw which cracked during heading when formed with sharp edges on the head. Eliminating the sharp edges resulted in successful heading of the same wire. The stress level in the head was lowered by avoiding the complete filling of the die cavity.

The severity of a cold heading operation can be measured both in terms of the head diameter ratio and by what shall be called the free length ratio. These ratios are calculated as shown in Fig 8.

The head diameter ratio indicates the severity of the spreading that occurs during heading. It is generally recognized that a head diameter ratio of three-to-one is a severe cold heading operation for austenitic stainless steels. Of course, head design must be considered at the same time. Nevertheless, very slight changes in head diameter ratio can produce significant results.

The free length ratio is also important because it indicates the length of wire which must be upset. High free length ratios may result in heading difficulties because of the tendency of the free stock to buckle and produce an eccentric blank. Free length ratios exceeding four are difficult jobs, but our experience has shown that recessed heads can be headed from No. 10 alloy with higher free length ratios when special techniques are employed.

As an example of how critical head diameter ratio can be, one screw manufacturer was able to eliminate compression cracks which occurred in a truss recessed head design by a slight reduction in the ratio from a No. 10 to a No. 9 head, a reduction in head diameter ratio from 2.87 to 2.74. However, the head diameter ratio for recessed heads must exceed a minimum value for any particular head design to keep the punch from splitting the heads. If the punch is too large for the head diameter, the head will split.

Theoretically, a free length ratio up to 2¼ can be upset in one blow. Unless special precautions are taken, higher ratios result in bending the wire instead of upsetting. With special tooling, several times the minimum length can be upset in a single blow. What is sometimes called a floating die or a spring loaded punch will cold head free length ratios up to 5.0, 6.0, 7.0, etc. in one blow. This type of header die exposes a free length of wire less than the critical 2¼ value while the wire is being expanded into the head. Even with this arrangement the dies must be properly aligned to prevent the formation of eccentric heads and resulting compression cracks.

Definite limiting values cannot be assigned to head diameter and free length ratios. However, a head diameter ratio greater than 3.0 is usually a critical value. With the No. 10 alloy, free length ratios greater than 4.0 have been headed successfully. Both ratios must be considered together when examining the severity of any heading operation. It is not difficult to visualize that a head design in which the free length ratio is one and the head diameter ratio is three could be a problem.

Fig 9 indicates how much spreading the No. 10 alloy will take. This shows 0.490 in. dia wire which was upset to a head diameter ratio of 2.75 while the free length ratio was only 1.2. Higher head diameter ratios become more critical when the free length ratio decreases. Thus, within the safe limits of these two ratios a high h/d_f free length ratio is less difficult to head than a high d/h_f ratio.

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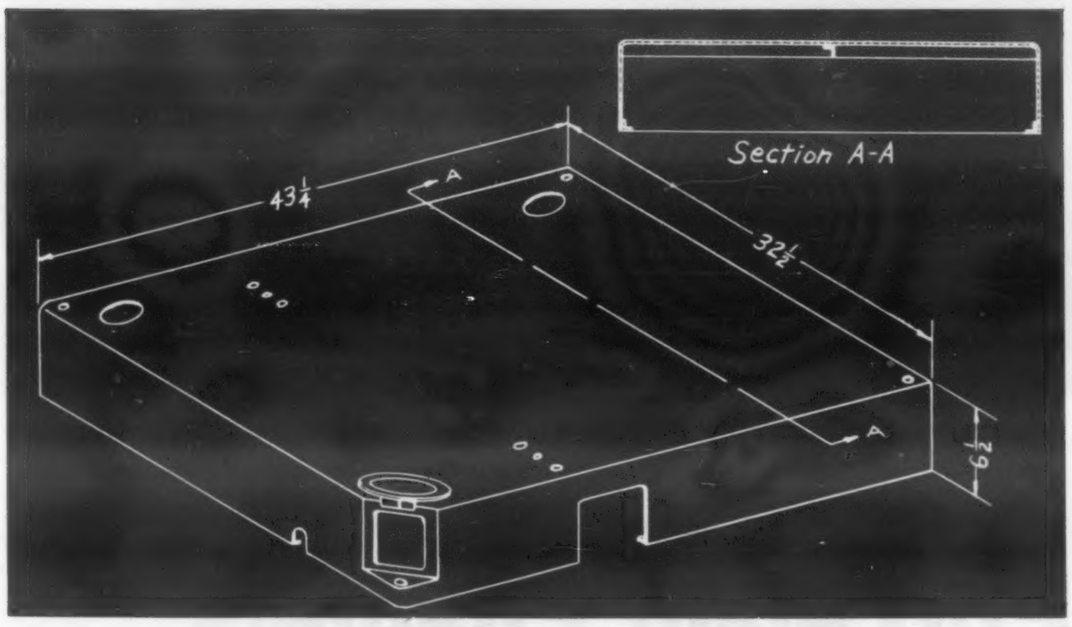
MATERIALS AT WORK



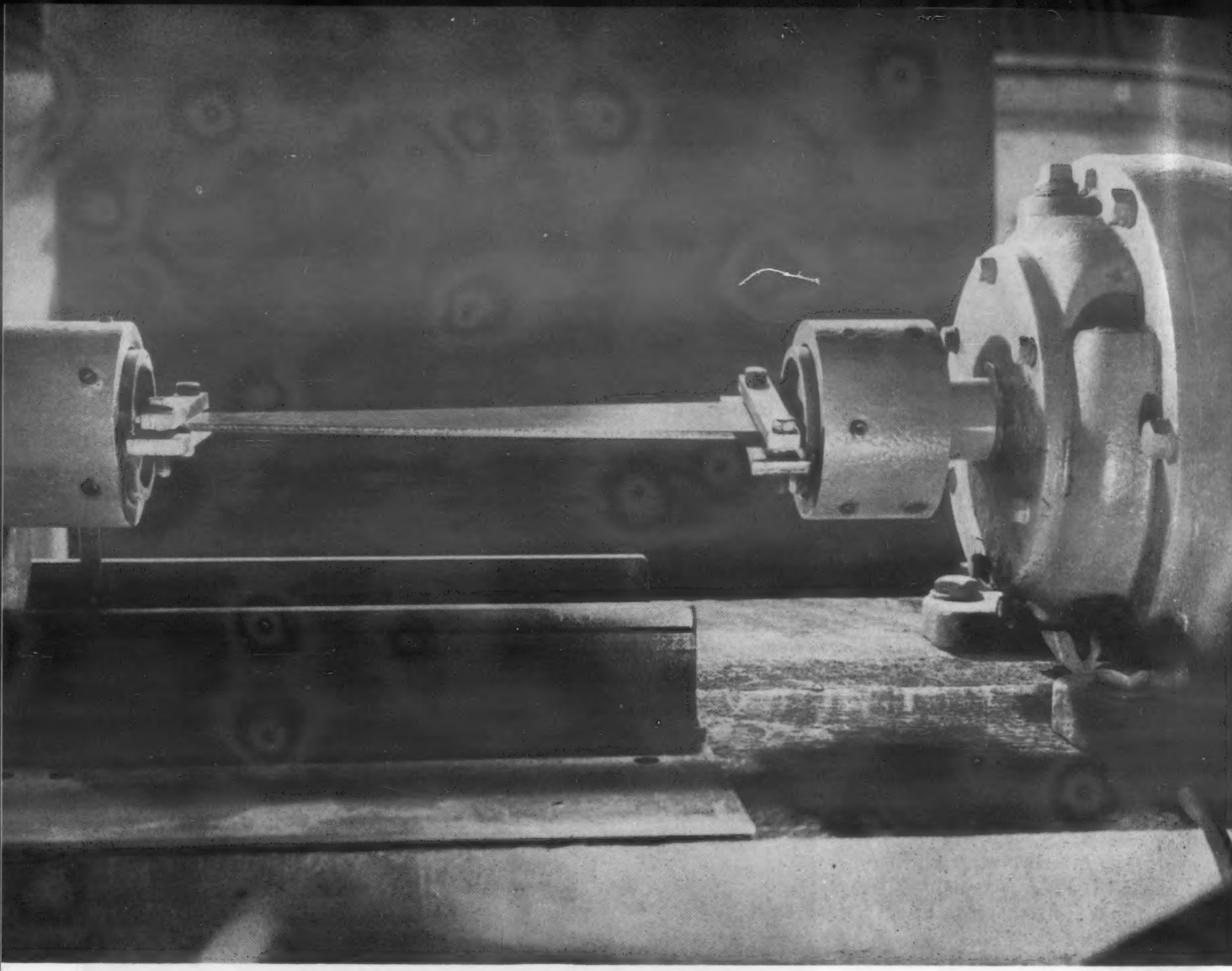
Case study: Steel weldment replaces aluminum casting

The preselector cover on a line of turret lathes was recently redesigned by Warner & Swasey Co. The cover on a prototype model was a 97-lb aluminum sand casting with 5/16-in. wall thickness. The aluminum casting was comparatively lightweight, had adequate strength for an unstressed part, could be styled to fit modern machine lines, and was thought to have good damping properties to minimize gear noise in head. Its cost, however, was high. An investment of more than \$1800 in pattern and flask was required. Material, casting and machining cost for each cover averaged about \$160.

In an effort to reduce cost, a welded steel cover was investigated. Because of steel's higher strength, 12-gage (0.100-in.) sheet could be used and no increase in weight was necessary. A right-angle frame was used for the base, as indicated in the accompanying sketch. Holes were punched instead of drilled and weldnuts took the place of tapped holes. These changes eliminated about 90% of the original machining cost. Manufacturing costs of the steel cover were slightly more than \$83, representing an important saving when measured against annual production of several hundred machines.

Detailed studies on noise shielding showed that lathes with fabricated steel covers were actually quieter than those with the prototype cover, probably because adequate ribbing and sufficient sheet thickness were used.

(Based on a prize-winning paper submitted by A. J. McClelland in the recent Machine Design Competition sponsored by James F. Lincoln Arc Welding Foundation.)



***Torsion resistance** is an important property of porcelain enamels in many applications.*

Porcelain Enamels: What the Properties Mean

Standard chemical, mechanical and optical tests can be used to predict the service performance of porcelain enamels. Interpreted properly, they allow the engineer to specify the best enamel for each application.

by James H. Giles, Jr., *O. Hommel Co.*

(Formerly with Porcelain Enamel Institute)

■ Many different porcelain enamels are available to the engineer and new coatings are continually being developed for new applications. To select the proper porcelain enamel—standard or tailor-made—it is necessary to know what properties of these coatings are important and how they can be evaluated and specified.

A number of standard laboratory tests for porcelain enamels exist. As is the case with all materials, these laboratory tests do not exactly simulate the condi-

tions a product is likely to encounter in actual service. By specifying certain minimum requirements on the basis of these tests, however, the engineer can be reasonably sure that the coating selected will perform satisfactorily.

This article describes the standard chemical, mechanical and optical tests for porcelain enamels, emphasizing the significance of each test for the specifying engineer. Details of testing procedures are not given here but may be found in the references cited in the accompanying box.

In specifying an enamel, of course, it is necessary to determine first just what properties are important in the application contemplated. It is particularly important not to over-specify a property or to specify a property that is not needed, for it is usually impossible to obtain an enamel that is well suited for a particular application without sacrificing one or more nonessential properties.

Careful attention to the distinctions between somewhat similar tests is also advisable. For example, two types of tests are used to evaluate the abrasion, resistance of porcelain enamels. These tests, referred to as surface abrasion and subsurface abrasion, are not necessarily related to each other. The test for surface abrasion resistance is intended to furnish an index of the enamel's ability to retain its appearance after being subjected to abrasion at or near the surface. The more severe test — subsurface abrasion — is intended primarily to furnish an index of the enamel's ability to protect the underlying metal from exposure. Where such protection is important, appearance of the enamel may be of little or no importance.

Chemical properties

Acid resistance at room temperature—In this test an enamel surface is exposed to a 10% solution of citric acid for 15 min at 80 F. After treatment the enamel is assigned to one of five classes —AA, A, B, C or D—depending on appearance of the attacked area and the extent to which it retains a soil.

For many applications acid resistance is of little importance. However, it is difficult to conceive of an enameled product that will not be subject to acid attack in one form or another, whether by the weak acids of citrus fruits or by concentrated mineral acids. On kitchen appliances where prolonged exposure to food acids may be encountered, enamels with an acid resistance rating of A or above are usually specified (e.g., Federal Spec. WW-P-542a and WW-P-211a). In applications where acid solutions are not normally encountered, such as heating stoves or bathtubs, the specification for acid resistance may not be required.

Boiling acid resistance—This test should be used for evaluating enamels that are to be exposed to hot acid solutions. It measures the weight loss of specimens exposed to a boiling 6% solution of citric acid for 2½ hr. The test is useful for measuring the potential resistance of kitchenware, which may be subjected to hot food acids, or of various types of laboratory equipment.

Weathering resistance— Weathering resistance is determined by means of the PEI (Porcelain Enamel Institute) acid resistance test. Porcelain enamels that possess an acid resistance of at least class B are usually able to withstand the weather elements for many years without becoming objectionably faded or etched. Although there are some exceptions, enamels of less than class B acid resistance usually exhibit poor weathering resistance.

Certain porcelain enamels possessing class AA acid resistance have recently exhibited objectionable fading during weathering. Used in signs, these enamels are usually bright red or orange and contain a cadmium-selenium pigment. The Porcelain Enamel Institute is now developing special tests for evaluating enamels of this type.

Alkali resistance—The need for good alkali resistance in porcelain enamels is fairly recent. It stems from increased use of highly alkaline detergents and automatic home appliances that operate at much higher temperatures than the manual equipment formerly used.

At present, there is no standard test for determining alkali resistance. However, a test method recently developed is being considered for adoption as a standard. A specimen is exposed to a solution of sodium pyrophosphate for a given period of time at a carefully controlled temperature.

Standard Test Methods—A Summary

Chemical	
Acid resistance, room temp	PEI T-7, ASTM C282
Acid resistance, boiling	ASTM C283
Weathering resistance	PEI T-7a
Alkali resistance	
Mechanical	
Abrasion resistance	PEI T-2
Torsion resistance	PEI T-5
Adherence	PEI T-17, ASTM C313
Thermal shock resistance	
Thickness	
Optical	
Gloss	PEI T-18, ASTM C346
Reflectance	PEI T-13, ASTM E97
Color	ASTM D307-44, D1260-55T, D1365-55T

Both weight loss and gloss loss (see "Optical Properties") are measured. Preliminary results indicate that the method is capable of differentiating porcelain enamels that possess different degrees of alkali resistance.

Mechanical properties

Abrasion resistance—Abrasion resistance of a porcelain enamel is determined by abrading a specimen for a given time with an abrasive charge of grit, steel balls and water. The specimen is secured to a flat, motor-driven oscillating table and the abrasive charge is placed on the surface of the specimen inside a retaining ring (see accompanying photograph). The table is then oscillated at 300 cycles per min.

In the test for surface abrasion resistance, the specimen is abraded for approximately 5 min, and percentage of original gloss retained is taken as the index of resistance. This test is particularly useful for home appliances to establish cleanability and resistance to deterioration in appearance.

The test for subsurface abrasion resistance is used primarily to determine how well the base metal is protected. The specimen is abraded for three successive 15-min periods, and the rate of weight loss is taken as the index of resistance. The test is particularly valuable for evaluating the performance of products such as coal chutes, screw conveyors, venturi tubes for jet pumps, and parts for farm equipment. Each product design should be examined critically to determine if good abrasion resistance is needed and, if so, which is more important: resistance to surface abrasion or resistance to subsurface abrasion.

Torsion resistance—Torsion resistance of porcelain enamel is determined by twisting an enameled metal angle until the enamel fails along the apex. The angle of twist at which failure occurs is an index of resistance to torsion. Good torsion resistance is needed for articles such as ranges or refrigerators that are likely to be subjected to bending or twisting during shipping, installation or subsequent moving.

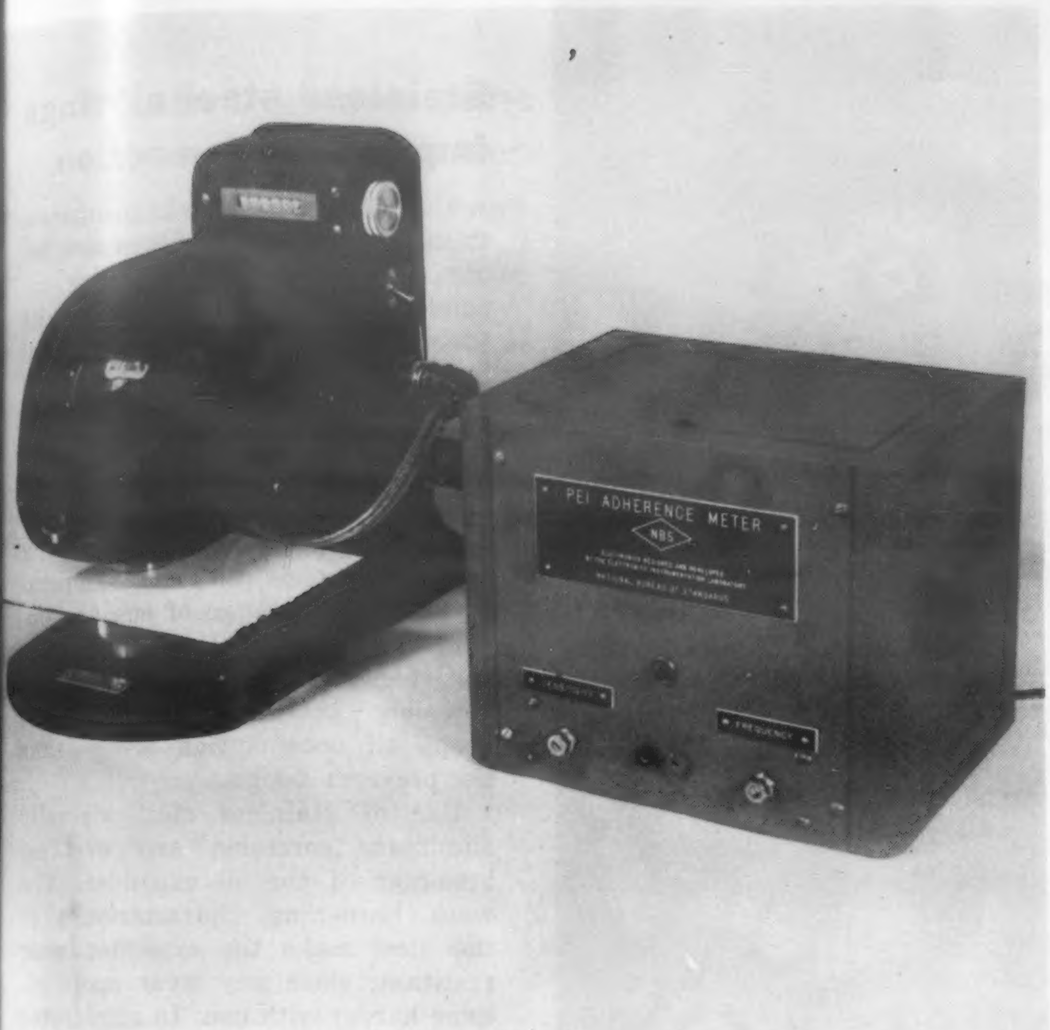
Abrasion tester *with nine specimens in place. Charge of grit, steel balls and water is retained by rubber coated cups clamped to specimens.*

Adherence—Adherence of porcelain enamels is determined by deforming an enameled metal specimen in a standard deforming press, then measuring the relative areas of exposed metal and adhering enamel. The adherence index obtained gives a reliable measure of the ability of the enamel to protect the base metal after it has been exposed to deformation. Adherence may range from 90% or greater for an enamel with good adherence to practically zero for an enamel with very poor adherence.

Thermal shock resistance—Porcelain enamels do not normally fail from thermal shock unless they are cooled very rapidly from a high temperature. Coatings quenched with water may crack or spall. Cooled in air, porcelain enamels will withstand repeated temperature cycling as high as 1000 F without damage.

A thermal shock test for porcelain enameled kitchenware recently adopted by the American Society for Testing Materials is performed by heating a specimen under controlled conditions for a specified time, then quenching it with a specified volume of water. After being examined for spalling, the specimen is subjected to successively more severe cycles until failure occurs or until it survives the prescribed number of cycles.

Another test method, now being considered for adoption as a PEI standard, is performed by heating a flat specimen to the test temperature in a resistance furnace, dropping water on the surface, painting the specimen with a dye solution, then washing it with soap and water. If the specimen retains a stain it is considered to have failed the test and the temperature at which failure occurs is taken as the index of resistance. Thermal shock resistance is important in a number of applica-



Adherence meter *contains a nest of metal probes (not visible) that are lowered onto deformed area of specimen. Adherence of enamel is indicated on automatic counter by the number of probes that make electrical contact with the base metal of the specimen.*

tions, such as kitchenware and laboratory and hospital equipment, where cracks that collect dirt and germs must be avoided. Thin coatings possess much better thermal shock resistance than thick coatings.

Thickness—Thickness is not actually a mechanical property, but the thickness of an enamel has a significant effect on such properties as torsion resistance and thermal shock resistance—both of which are higher for thinner coatings. Thinner coatings can often be obtained by using enamels having greater opacity or hiding power.

There is no standard method for determining thickness of porcelain enamel coatings. However, a number of instruments based on magnetic principles are available that can establish enamel thickness quite accurately.

Optical properties

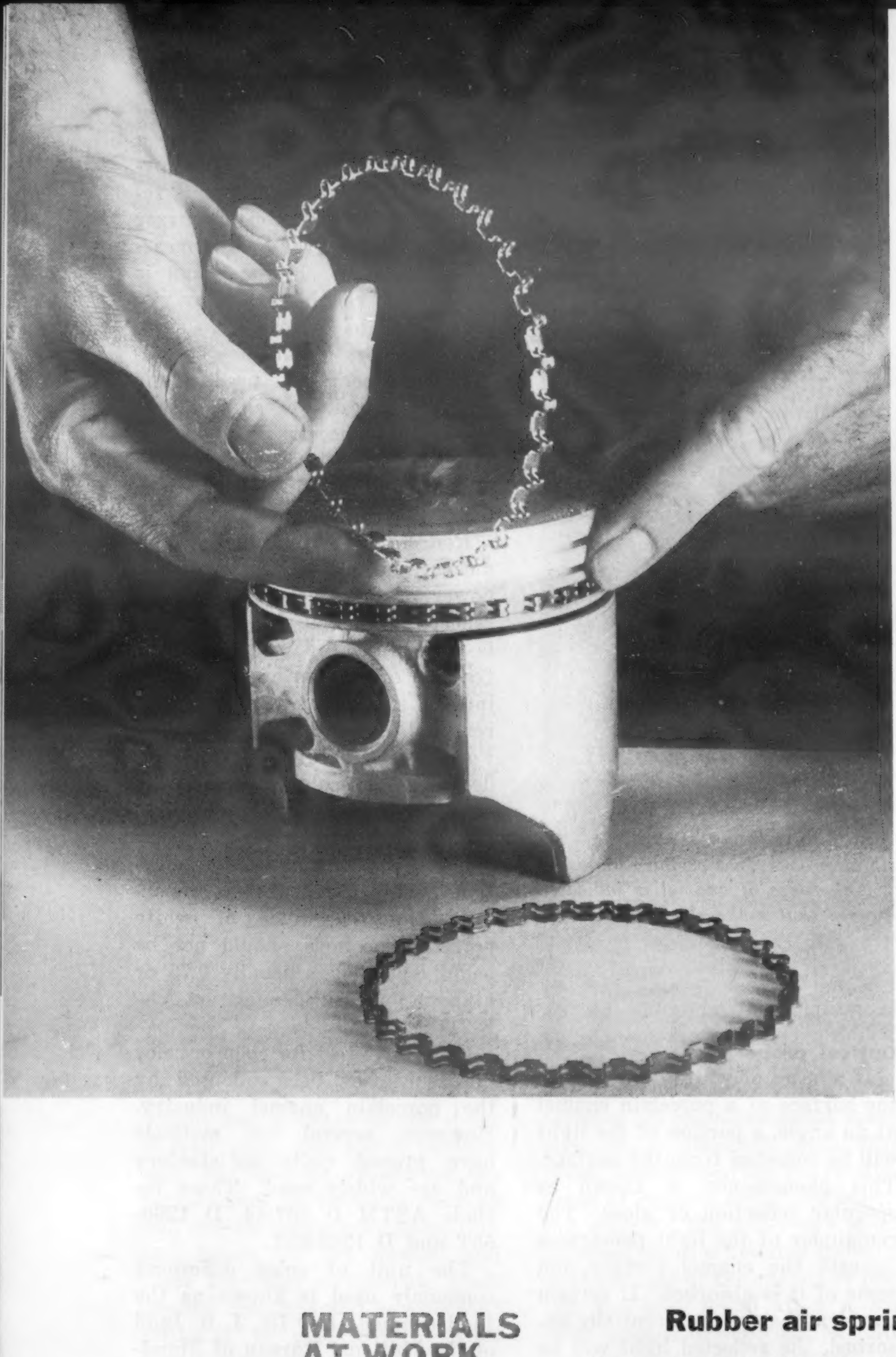
If a beam of white light strikes the surface of a porcelain enamel at an angle, a portion of the light will be reflected from the surface. This phenomenon is known as specular reflection or gloss. The remainder of the light penetrates beneath the enamel surface and some of it is absorbed. If certain wavelengths are preferentially absorbed, the reflected light will be colored, and hence the enamel is said to be colored. The actual color perceived is a function of the spectral distribution of the reflected light. All of the light that is not specularly reflected or absorbed is refracted and reflected within the enamel and is eventually emitted from the surface. This process is called diffuse reflection, and the fraction of the incident light so reflected is called the reflectance of the enamel.

Gloss—The specular reflection or gloss of an enamel is determined by measuring the fraction of a beam of light falling on the surface at a 45 deg angle that is reflected in the direction of mirror reflection. This value is a measure of surface shininess and is much more reliable than any visual estimate. However, since specular gloss is only one of several phenomena that produce the visual impression of shininess, it may also be necessary to specify the color, reflectance and texture of an enamel in applications where appearance is important.

Reflectance — Reflectance is a measure of the "lightness" or the power of a porcelain enamel to reflect light. Diffuse reflectance is determined by measuring the fraction of a beam of light striking the surface at 45 deg that is reflected normal to the surface. For lighting fixtures the total reflectance (specular plus diffuse reflectance) should not be less than 0.85 (Federal Specification WF-00-412). In other applications where appearance is important, the reflectance of white porcelain enamels should not be below 0.65 and is usually 0.75 or higher (Federal Specification AA-R-211b).

Color—No test for color or color difference has been adopted by the porcelain enamel industry. However, several test methods have proved quite satisfactory and are widely used. These include ASTM D 307-44, D 1260-55T and D 1365-55T.

The unit of color difference commonly used is known as the judd (named after Dr. J. B. Judd of the National Bureau of Standards). It is generally accepted that a color difference of one judd is about five times the minimum that can be detected by the average observer. The amount of color difference that can be tolerated depends upon the color and size of the objects being compared, distance between objects, background, type of lighting and other factors. Hence, the establishment of color tolerances usually requires visual observations as well as physical measurements.



Stainless steel oil rings improve piston action

A chromium - nickel - manganese stainless steel, Type 201, is now being used in a piston oil ring expander-spacer. The steel gets its spring properties from the actual forming operations necessary to produce the part and needs no further hardening operations after forming. Only a low temperature stress relieving operation is required. In addition, the stainless steel ring maintains more uniform temperatures over the range of engine temperatures than the conventional carbon steel ring. Thus the piston ring assembly is more accurate—and keeps oil consumption lower—than the previous design.

Use of stainless steel virtually eliminates corrosion and eventual breakage of the oil expander. The work hardening characteristics of the steel make the expander wear resistant, since any wear spots become harder with use. In accelerated laboratory fatigue tests the new assemblies have shown that they can go for more than 450,000 miles without breaking.

It is expected that the new stainless steel rings, developed by Sealed Power Corp. in cooperation with Allegheny Ludlum Steel Corp., will be available for replacement in older cars sometime in the second quarter of 1957.

MATERIALS AT WORK

Rubber air springs make riding easier

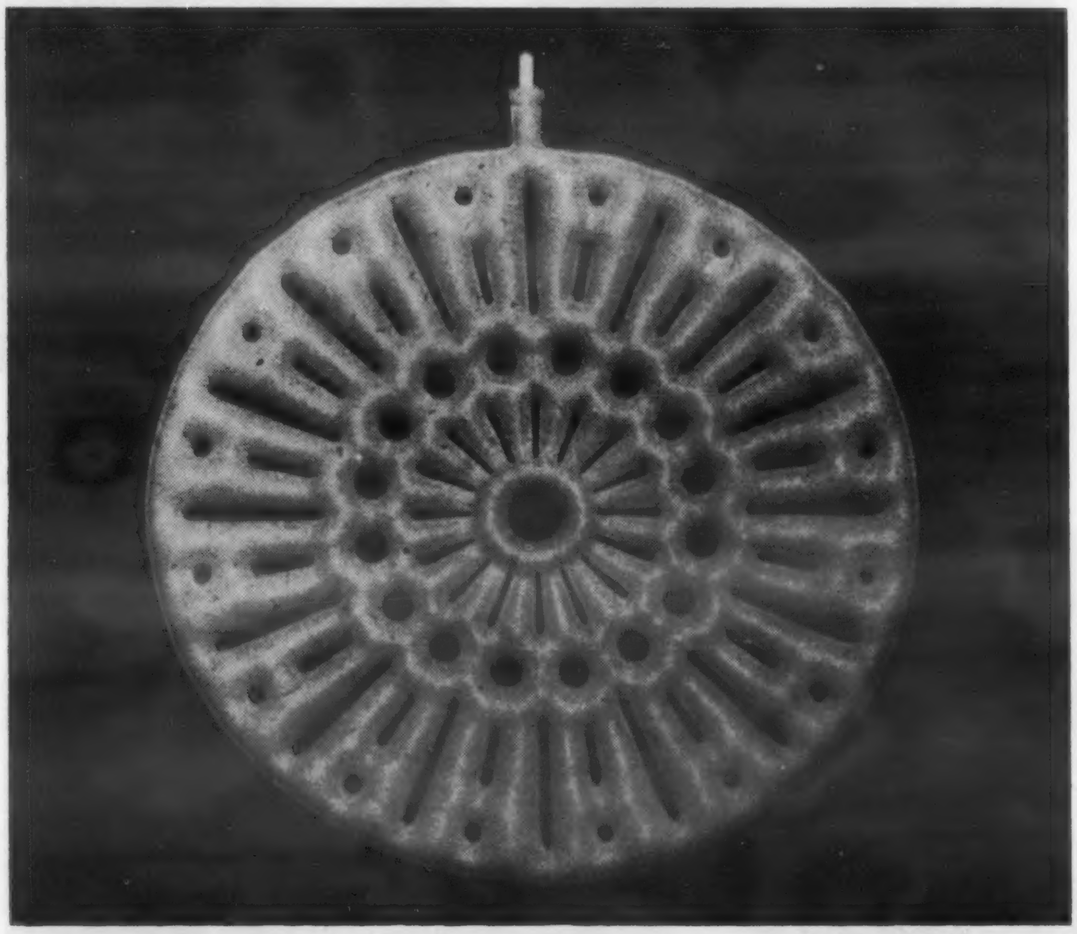
More and more trucks and trains are being furnished with rubber air springs and, according to Firestone Tire & Rubber engineers' use of air springs on passenger cars may be expected within a year or two. Based, like a tire, on the principle that air can be compressed, an air spring absorbs driving shocks without passing them on to the body of the vehicle. It never needs lubrication or replacement and has no metal bearings to squeak or suffer metal fatigue.

Consisting of a rubber "bellows" with steel rings around the center and at each end, air springs are installed two or four to an axle and interconnected by a system of valves and air tanks.

Fabricating the bellows is basically like building a tire. High strength nylon cord fabric impregnated with rubber is built around a drum in plies, with strong rubber and steel beads locked in at each end. The bellows is then placed in a mold where it is cured and shaped in a steam press. The finished part is then inspected for leakage or other flaws.

Plastics window pane screens out ultraviolet

A window made of polyester-glass reinforced plastics plus special ingredients permits 50% of natural light to pass through, but keeps out ultraviolet rays. Developed by Reinforced Plastic Div., Firestone Tire & Rubber Co., the panes are used in warehouses storing materials that can be harmed by ultraviolet light. The panes never need painting and are almost unbreakable. A hard blow with a hammer leaves only a dime size scar. Easier to clean than ordinary glass, they resist chemicals, smoke and smog.



These are . . .

■ Seamless hollow shapes are produced from single strips or sheets of rubber or plastics by an interesting new process developed in Germany. Tubing and complex shapes can be produced in natural or synthetic rubber. Tubing and simple shapes can be produced in thermoplastic resins. Though said to be particularly suitable for use with cellulosics, the process, called Holofol, is also adaptable to other thermoplastics such as polyvinyl chlorides and polyamides.

This new method of making hollow shapes eliminates not only the need for a second sheet but also the need for welding or heat sealing. Hollow figures are produced individually, but tubing can be produced continuously. Formed parts are said to have consistent properties in all areas. Aging stability of parts is also reported to be good.

Essentially, the process causes the dissolution of material in an area equidistant from the faces

***Complex and simple shapes** can be economically produced.*

Seamless Hollow Shapes of Rubber or Plastics

They are made from single sheets or films by a unique process developed in Germany.

and the edges of the strip or sheet. Under heat, the dissolving agents turn into a gas which swells the walls, forming the hollow shape. By precise cutting of strip of the proper thickness, it is possible to produce tubes with diameters ranging from about 0.05 to over 40 in.

Rubber parts

Inflatable rubber shapes are produced by stamping out the desired shapes from flat sheet before subjecting them to the process. Complicated three-dimensional shapes, such as toy animals, can be made by cutting out additional shapes from flat sheet and attaching them to the main sheet before expanding. Shaped and embossed sheets can be used as well as flat materials. However, thickness of a boss must not exceed 25% of total sheet thickness.

Shapes are stamped out of unvulcanized sheet rubber, then put on a conveyor belt to be carried through an automatic machine. The machine first vulcanizes the rubber, leaving a thin unvulcanized core zone which represents about 5 or 10% of total thickness. Parts are then washed and passed through a swelling bath, followed by a heat treatment which expands the part. The expanded articles are then vulcanized and powdered.

Products for which the process has been used include hot water bottles, beach and sanitary cushions, mattresses, bicycle and motorcycle tire tubes, technical tubing, surgical gloves, inflatable toy animals and balloons.

Plastics parts

Most plastics parts produced by the Holofol process have been of cellulose acetate or other cellulose materials. However, through variation of bath composition, other thermoplastic materials can be used. By proper control of the process, physical and mechanical properties of the end part can be altered as desired. For example, plasticizers can be added to or extracted from the plastics during treatment to produce materials with the desired degree of stiffness.

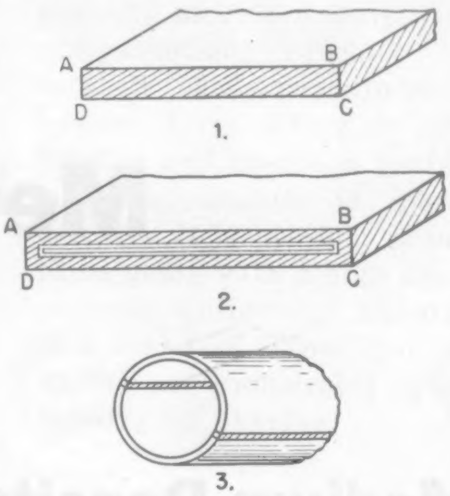
Processing time for cellulosics ranges from several seconds up to a few minutes. For other types of thermoplastics, from 1 to 5 min per 0.004 in. of sheet thickness is required at ambient temperatures. Processing time can be altered by changing bath composition.

Since the edge of the sheet becomes a part of the principal surface of the inflated part, the condition of the edges is quite important. Rubber sheeting presents no edge problem since edges are obtained by cutting. The edges of plastics sheet require special attention, however, and methods have been devised for producing more suitable edges.

The process has been used to make products such as surgical finger stalls, surgical gloves, bandages, tube rings, sausage casings, synthetic bladders, meat and lard wrappers, technical tubing and transparent envelopes and bags.

Adapted from technical literature of Walter Opavsky Laboratories (Germany).

The Holofol Process



How it works

To understand the process, film must be considered as a three-dimensional form as represented in sketch 1. The edge of the film, area ABCD, must then be considered as a surface.

The first step of the process consists in immersion of the strip in a bath composed of swelling agents and solvents. The strip swells, increasing area ABCD. After a predetermined amount of swelling, heat is applied. The heat dries and shrinks the outer surfaces of the strip. This combination of drying and shrinking drives the residual bath mixture to the center of the area ABCD (sketch 2) where the mixture is converted into gas. As the solvent-swelling agent mixture is converted to gas, it swells the core area, forming the hollow shape shown in sketch 3.

Controlling the type and quantity of chemicals and the process time and temperature allows production of a seamless hollow shape of predetermined properties in a single continuous process.

Availability

The Holofol process is a development of the Walter Opavsky Laboratory, Coburg 3, Germany. It is currently being used in Europe to produce sausage casings, packing materials, sanitary articles and bottle capsules. Machinery has been designed and built for the process and is available on a licensing basis in this country.

Three experts present facts that will help you decide . . .

Which Metal Powder Part?

Among the many variables affecting the properties of metal powder parts, density is one of the most important. At a recent Metal Powder Association meeting, a panel of experts discussed intermediate density, high density and infiltrated iron powder parts. Their presentation affords a direct comparison of the materials and will give the designer an idea of which he should choose for a given application.

Medium Density

by Robert Talmage, *Consultant*

Medium density iron parts fall within the range of about 6.2 to 6.8 gm per cu cm. Mixtures of iron and copper powders are generally used. They are pressed at relatively high pressures and sintered at temperatures around 2000 to 2100 F in protective atmespheres.

The advantages of medium density steel parts are: 1) low cost, 2) relatively high yield strength, 3) lack of brittleness and 4) excellent wear resistance resulting from controlled internal porosity making self lubrication possible, when pores are oil-filled. Because of these advantages, medium density parts should find a constantly broadening field of application. Their ability to perform satisfactorily under rather high stress conditions and to improve the life of various mechanisms will result also in increasing use.

To show what can be expected of medium density iron powder parts, the properties and applications of a typical composition will be given. The parts are produced from the following mixture:

94 parts of 100 mesh iron powder (standard, low cost, reduced type)

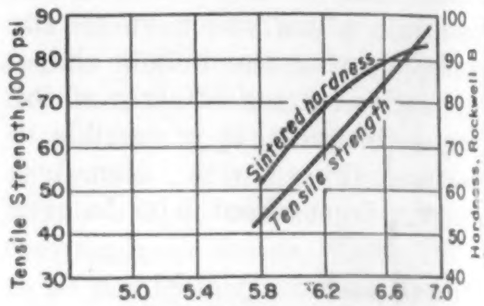
5 parts of 100 mesh copper powder (standard electrolytic or reduced type)

1 part of 325 mesh graphite powder

1 part of zinc stearate

This mixture is pressed at relatively high pressures to a density of 6.2 to 6.8 gm per cu cm and sintered at 2050 F in dissociated ammonia for a period of 15 min at temperature. No second pressing or sintering is used. A tensile strength of 60,000 psi is obtained at a density of 6.2 and this increases to 80,000 psi at a density of 6.8. Most parts are produced, however, in the 6.2 to 6.6 range and have tensile strengths in the range 60,000 to 73,000 psi. The elongation is about 1%. Rockwell hardness ranges from R_b75 to R_b90.

In many applications, design engineers ask that a sintered steel be as strong as normal wrought low carbon steel strip and bar stock. Hot rolled low carbon steels have yield strengths ranging from 30,000 to 40,000 psi, while cold rolled material has values up to 70,000 psi. Therefore, when it is noted that this low cost sintered steel has yield strengths of 55,000 to 75,000 psi in the 6.2 to 6.6 density range, it is apparent that the material satisfies the strength requirements for many applications.



***Density vs strength** and hardness of medium density parts.*

Typical parts produced from the sintered steel are a margin stop for a standard office typewriter, a pinion for a high speed mechanical counter and a roller chain bushing for a power transmission chain.

High Density

by William J. Doelker, *Supermet Div., Globe Industries, Inc.*

High density, iron-base materials are those having densities above 6.8 gm per cu cm. They are produced primarily of pure electrolytic iron powder to which only carbon has been added.

High density iron powder parts are finding wide application particularly in parts where the characteristics of lower density products are not quite good enough to meet the service requirements. Included are applications where a high degree of dimensional accuracy must be maintained, greater strength is required, a lower porosity is necessary, higher impact strength and wear resistance must be developed, or superior surface finishes must be provided and maintained.

Parts are produced either by mixing graphite with the iron powder before pressing or by gas carburizing after the part is formed. Gas carburizing is preferred. Depending on shape, parts

are pressed to an initial density of 6.8 to 7.3 gm per cu cm. After sintering, these parts have tensile strengths of 27,000 to 36,000 psi, yield strengths of 19,500 to 24,500 psi and elongations in the range 7 to 10%. After carburizing, hardening and tempering, the tensile strength ranges from 40,000 to 95,000 psi, the yield strength is practically the same as the tensile strength, and the elongation ranges from 0 to 5%, depending on whether the parts have been fully hardened or on the degree of tempering.

If parts are given a second sintering operation, they will develop tensile strengths of 43,500 to 48,000 psi, yield strengths of 27,500 to 29,000 psi and elongations of 11 to 25%. Parts given this treatment will exhibit maximum mechanical properties upon being carburized and hardened. Depending on the amount of carbon added, the depth to which these parts are carburized, and the tempering, these parts can have tensile strengths ranging from 90,000 to 200,000 psi, yield strengths of 78,000 to 200,000 psi and elongations of 0 to 4%.

High density parts have a maximum porosity of 13.6% at 6.8 density and a minimum of 2.8% porosity at 7.65 density.

Applications include cams, ratchets, pawls, parts to be copper brazed, parts acting on or with plastics and precision gears. The latter application is increasing greatly. It is possible to produce these gears with a high degree of accuracy, uniformity, and strength at a cost well below that of producing a comparable gear by hobbing or shaving.

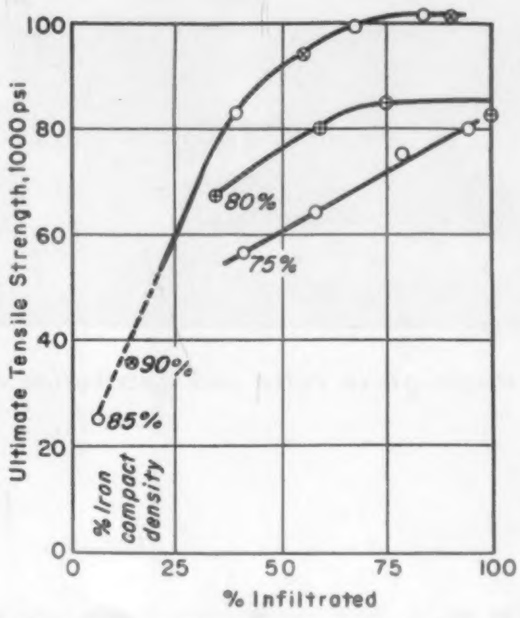
Infiltrated **by Carl G. Johnson,** *Presmet Corp.*

Infiltrated parts are generally prepared by producing an iron powder skeleton having a density in the range 6.0 to 6.2 gm per cu cm and infiltrating the skeleton either with copper or a copper-base alloy.

The major purposes of infiltration are, 1) to increase the strength and hardness and 2) to obtain uniform density. It is easier to obtain uniform density by infiltration than by pressing and sintering without infiltration, particularly in parts having nonuniform sections. It is impossible to obtain densities in the range 7.1 to 7.6 gm per cu cm in many parts without resorting to infiltration.

In the production of these components, the part to be infiltrated is pressed from iron powder, a blend of iron and graphite powders, or a blend of iron, copper and graphite powders. This skeleton is generally pressed to a density of 6.0 to 6.2 gm per cu cm which is approximately 77% of theoretical density. After pressing, the part is pre-sintered at about 1900 to 2050 F. Either copper or brass is used for infiltration. The 90-10, 85-15 and 70-30 brass compositions are generally used, although 85-15 is preferred. By using brass in place of copper, infiltration can be done faster, at a lower temperature and with less erosion than when copper is used. In the infiltration cycle an infiltration blank is placed on the preform and both parts are heated to a temperature that will melt the infiltrant and held at this temperature for sufficient time to allow infiltration.

Infiltrated parts have densities ranging from 7.1 to 7.6 gm per cu cm. Typical mechanical properties are, tensile strength 65,000 to 100,000 psi, elongation (in 1 in.) 0.5 to 1%, compressive yield strength 70,000 to 120,000 psi and Rockwell hardness ranging from R_b30 to R_b80.



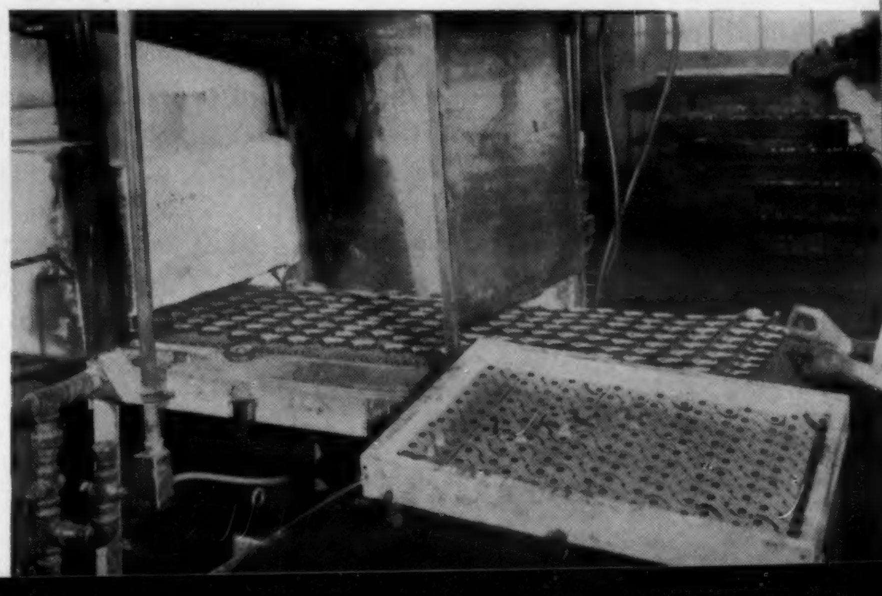
Effects of infiltration *and density on tensile strength.* *(George Stern)*

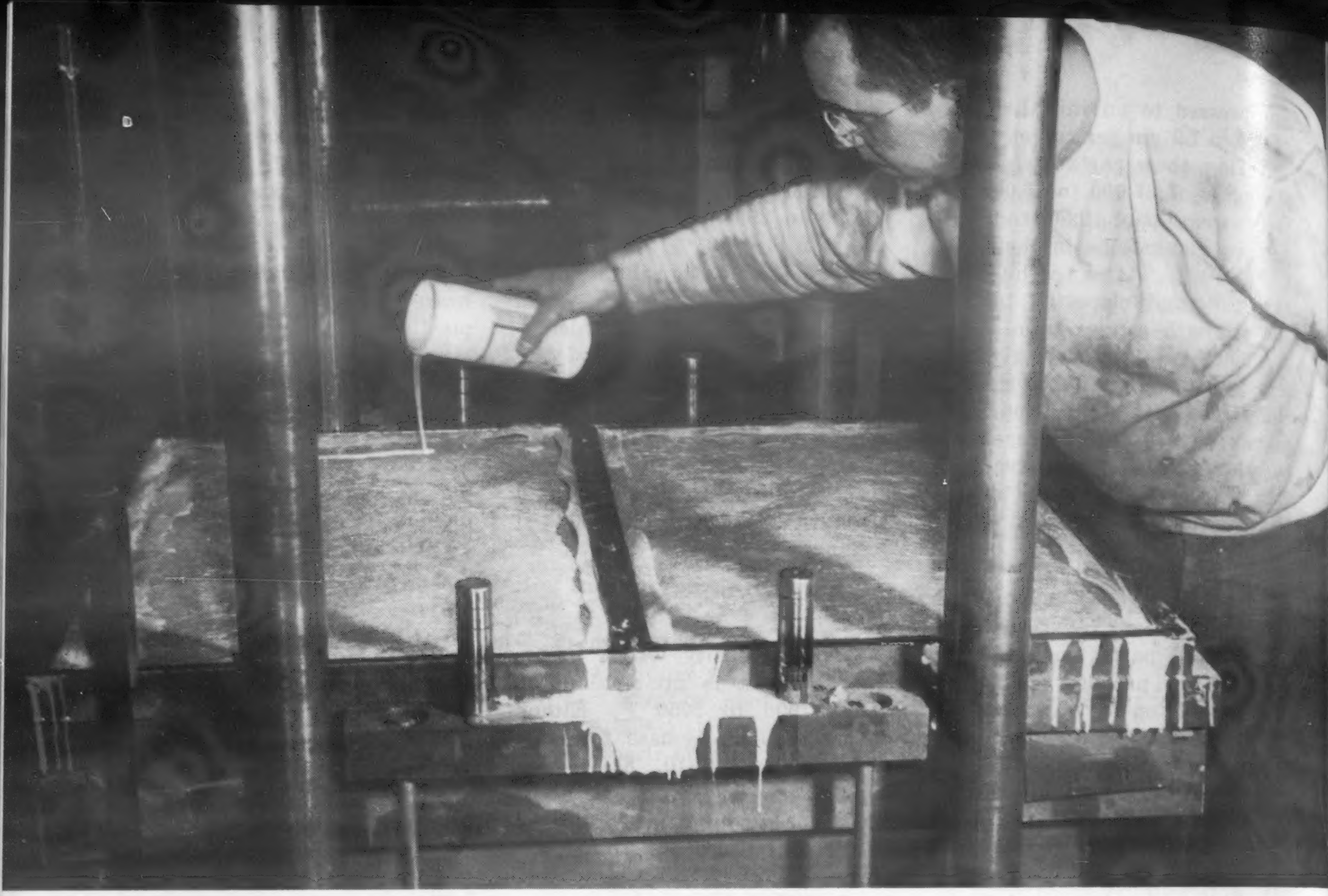
Applications include gears and numerous small parts, particularly those having combinations of light and heavy sections which are difficult to press to uniform density.

Adapted from a panel discussion at the Apr. 1956 meeting of the Metal Powder Assn.

Iron-graphite preform *and brass powder infiltrant blanks (bottom) together with die, punches and core rod used to make them.*

Brass replica *is being placed on top of preform for start of infiltration cycle.*





Owens-Corning Fiberglas, Inc.

***Resin-glass ratio** and distribution of resin must be carefully controlled.*

How to Get Good Parts in Reinforced Plastics

A molder tells prospective users why good design and good quality control are essential.

by Maurice Martin, *Vice President, Bassons Industries Corp.*

■ Many designers and engineers who specify materials are oriented in terms of metals and do not realize the controlling variables of reinforced plastics. In many cases specifications are based primarily on physical and mechanical property data listed as typical for a certain type of resin with a certain type of reinforcing material. These data are general and do not usually take into account the effects of design and methods of fabrication or molding on end properties. In reinforced plastics especially, the method of fabrication or molding and the control exercised over it has a direct effect on physical and mechanical properties of the cured part.

In comparison with sheet metal, reinforced plastics are heterogeneous materials subject to a great number of variables, each of which can seriously affect end properties of the material. Resin systems can employ different cat-

alysts, hardeners and fillers. Reinforcement can consist of cloth, random fiber or mat and may be made of glass, asbestos, sisal or synthetic fibers. In combining the reinforcement with the resin, varying proportions can be used. And compounding these variables is the variety of molding methods and cures. All of these variables must be carefully specified and controlled to ensure optimum quality parts.

Design factors

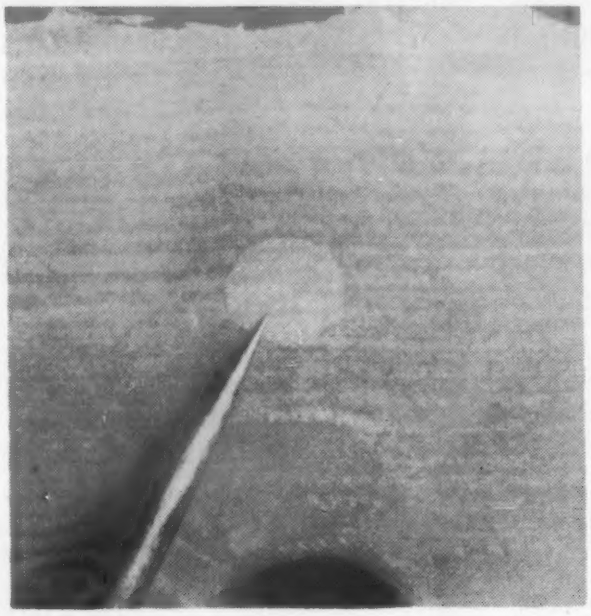
Though standardization of design factors is far from complete in the reinforced plastics industry, design criteria do exist. When these criteria are observed together with the proper safety factor, they can result in a well conceived design. Wherever possible, original design of a part should be worked out with the technical assistance of the plastics molder.

Draft — Matched metal (male and female) molding techniques are used for producing the most accurate reinforced plastics parts. Designing for proper molding techniques requires that allowance be made for a minimum of ½ deg draft or slope on the side walls of parts to permit easy removal from the mold.

Radii — During the molding cycle, viscosity of the resin becomes very low and the reinforcing material tends to pull away from the female mold to the corners of the male mold. If this is allowed to happen the outer corner of the part becomes resin-rich, with little reinforcement, and the inner corner becomes resin-starved. This inhomogeneity can be prevented by providing ample radii in such corners. In addition to maintaining better positioning of the preform, ample radii allow better flow of the resin, speeding production and producing parts with greater consistency of quality.

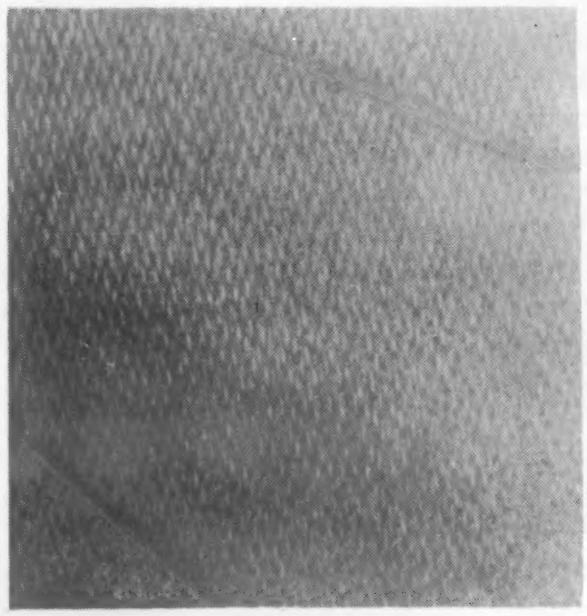
It is impossible to designate a definite minimum radius which should be used, since it depends on contour of the piece, ratio of depth of mold to opening and other factors. The inside radius should be no less than the wall

How to Recognize Defects in Reinforced Plastics

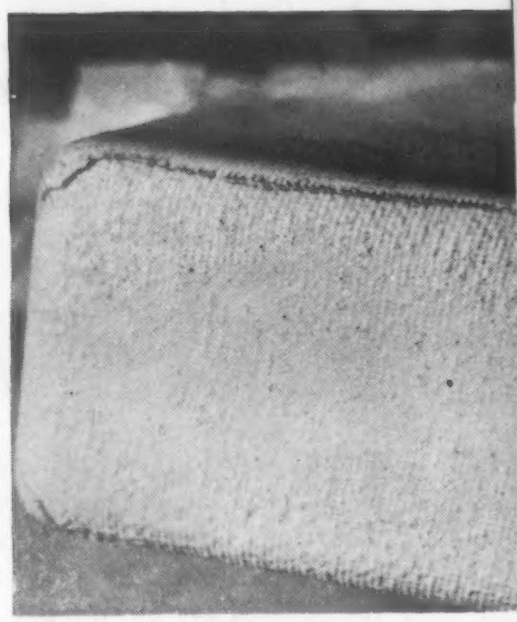


Blister

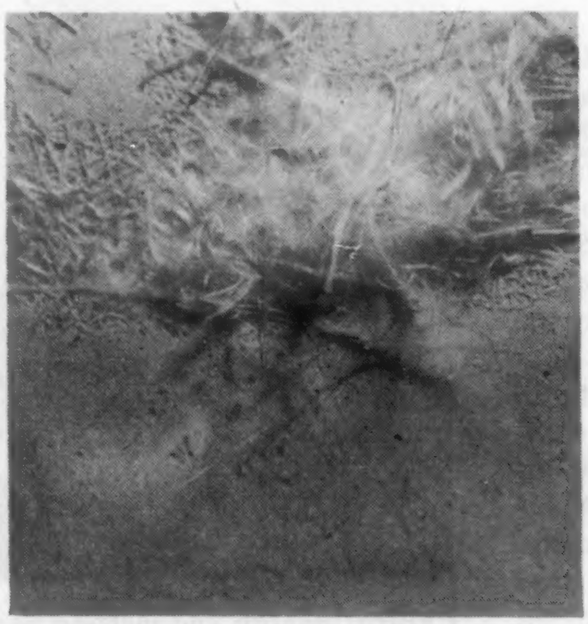
Excess resin



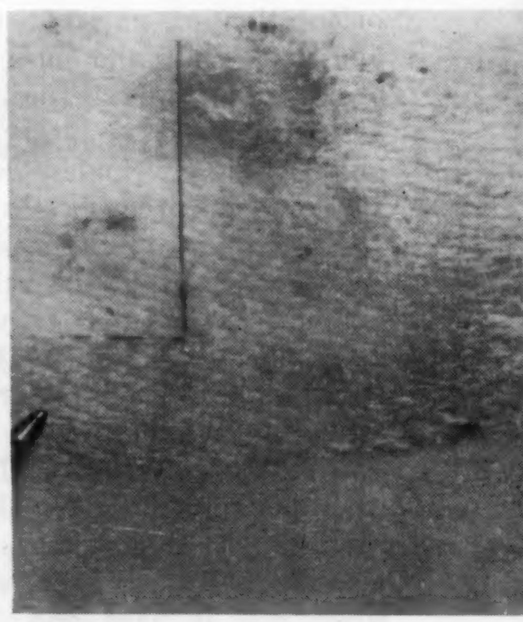
Wrinkles



Resin-starved area



Excess glass



Pits

thickness, but the minimum, unless the molder is extremely careful, should be no less than ⅛ in.

Tolerances—In general, dimensional tolerances in reinforced plastics are somewhat tighter than in sheet metal fabrication, but wider than those which can be expected in the machine shop. Accuracy to which a molder can work depends to a great extent on the accuracy of the molds. Ordinarily, tolerances which can be held on a reinforced plastics part are about four times those held on the mold.

Use of kellering and other machining methods can result in highly precise dimensions and wall thicknesses. However, the designer should bear in mind that the closer the specified tolerances, the higher the cost of tooling and thus the higher the cost of the part. Specifying the maximum permissible tolerances results in maximum ease of production, minimum rejects, most economical tooling and, consequently, the lowest cost part.

Variations in quality

There are a number of variations in the quality of reinforced plastics parts which are due to forming or molding variables. Such variations occur both within a molding and from molding to molding. Only by intelligent design and the use of a careful quality control system during fabrication can these variations be avoided or minimized. Some of these variations are: nonuniform orientation of glass fibers, gaps and laps, cracks and holes, blisters or air pockets, resin pockets and excess surface resin, starved areas and porosity, wrinkles, delamination, and uncured or tacky areas.

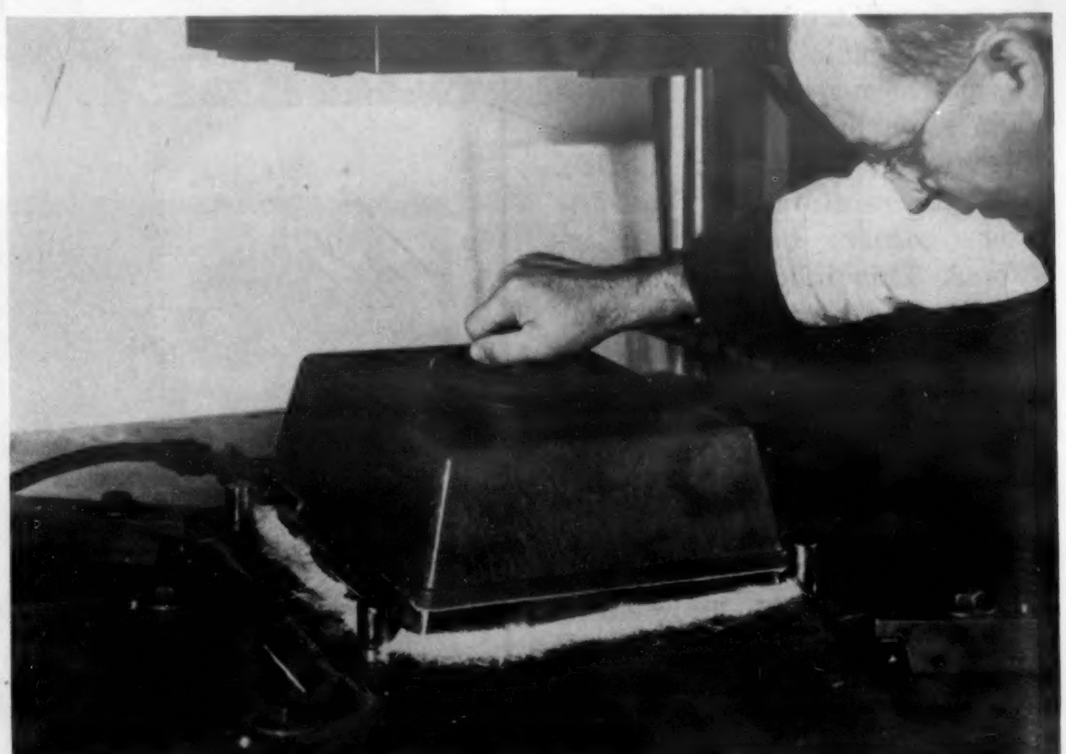
Nonuniform orientation—Since the strength of a glass-reinforced laminate is due primarily to the glass fibers, one factor that contributes to lack of uniformity in strength is nonuniform orientation of the glass fibers. In a finished molding the glass fibers are usually in somewhat random placement. This is especially true when mat is used and is often true when cloth is the reinforcing medium. Furthermore tensile strength of most cloths varies in different directions because of differences in the number of threads per inch, method of weave, etc. In an attempt to equalize strength in all directions, a cloth laminate is usually built up by placing the weaves of alternate layers at right angles to each other. Despite attempts to minimize the effect of random placement of glass fibers, the strength of a molded part does vary in different directions.

Gaps and laps—Gaps in reinforcing material and areas where reinforcement overlaps are caused by the tailoring of the preform. Making a preform for any but the simplest shapes requires tailoring a pattern in the cloth or mat. The possibility of deviating from the original pattern, even when proper precautions are taken, is obvious. Such deviations can result in gaps or laps when the reinforcement is draped in the mold and the molding operation completed.

Other variations—Most of the other imperfections are due to the heterogeneous nature of the material and the fact that it is usually manufactured at low pressures on inexpensive tooling. It is not always possible to control the proportion of resin to glass so that it is precisely uniform throughout the entire molded piece. Pressures developed by conventional molding methods do not always ensure uniform flow of resin throughout the part.

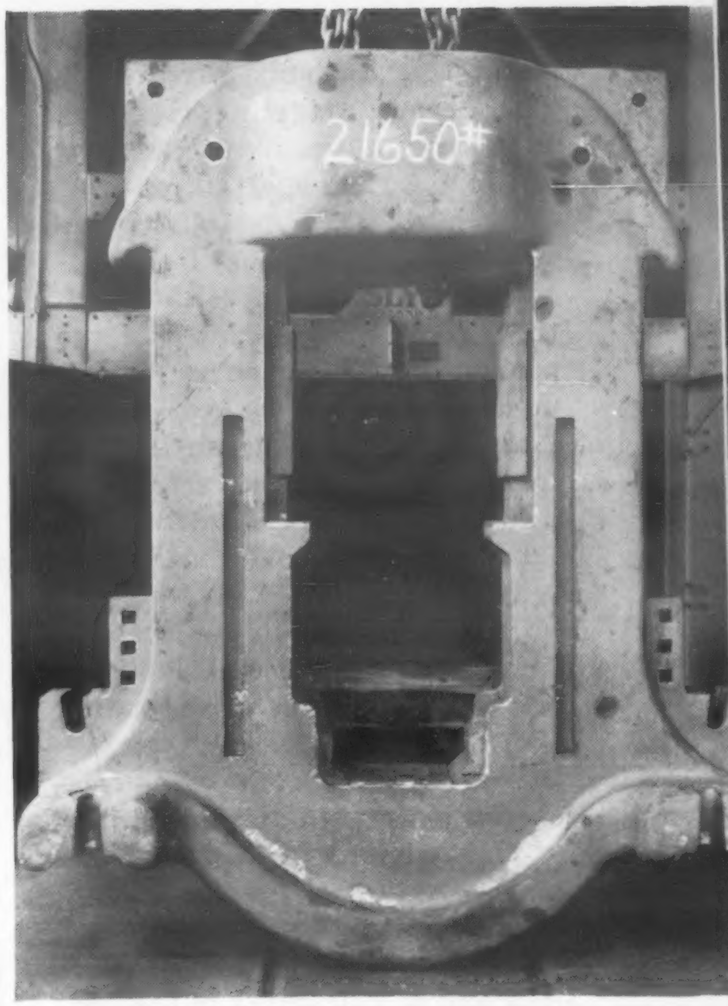
Other factors which cause lack of uniformity in strength from molding to molding are slight variations in thickness, differences in the amount of entrapped air and variations in the temperature, pressure and length of cure employed in the molding process.

Careful quality control during manufacture, proper molding techniques and somewhat more expensive tooling can keep all of these variations to a minimum, but it would be unrealistic to deny the possibility of their occurrence. These factors should be considered either during the design of the piece or at the time when the use of reinforced plastics for a particular product is being decided. They should not deter the designer or the end user from using a material that is so superior to other available materials in so many varied uses. When the designer is fully aware of these variations and their causes, and when the magnitude of these variations is limited by proper quality control, parts can be designed realistically and produced to the satisfaction of the end user.



Owens-Corning Fiberglas, Inc.

Careful design *and molding permit relatively sharp corners without danger of resin-rich or resin-starved areas.*



Gray Iron Castings

by Robert J. Fabian, *Associate Editor, Materials & Methods*

The low cost of gray iron combined with its excellent machinability, castability and damping capacity, and its resistance to heat, wear and corrosion accounts for its wide popularity as a basic engineering material. Because of its low cost and availability, gray iron deserves primary consideration whenever a cast metal is being selected. The purpose of this article is to present the engineer with all of the basic data needed for intelligent design. Included are:

- *Engineering properties*
- *Design considerations*
- *Heat treatment, finishing and joining*
- *Applications*

■ Cast iron is a broad term encompassing a family of materials with a wide range of properties. In general, a cast iron is an alloy of iron, carbon and silicon that ordinarily is not usefully malleable as cast. Gray cast irons possess a chemical composition such that after solidification a large portion of the carbon is distributed throughout the casting as free or graphitic carbon in flake form. Carbon content varies from 2 to 4% and silicon content from 1 to 3%. The material presents a gray surface when fractured.

Since gray iron is the least expensive of all first metals it should always receive first consideration when a cast metal is being selected. Other metals should be chosen only when the mechanical or physical properties of gray iron are not suitable.

Gray iron possesses the highest fluidity of the ferrous-base castings and is well suited to the production of intricate and comparatively thin-walled castings. It tends to free itself of entrained gases and inclusions more rapidly than most light metals. Important from a design viewpoint is its low solidification shrinkage—from 0 to 1.9%. Comparable shrinkage for steel or malleable iron is about 5.0%. Also, the contraction of gray iron after solidification is about one-half that of most cast metals.

Because of its excellent fluidity and low shrinkage, gray iron permits full utilization of the high degree of design freedom possible in the casting process. Stresses developed during solidification are low, and the majority of gray iron castings are put directly into service without the stress relieving, normalizing or malleabilizing heat treatments required by other ferrous metals.

Gray iron offers a wide choice of strength and hardness in the as-cast condition. By control of analysis it is possible to produce materials ranging from a soft type with the best machinability of any known ferrous material, to a harder type whose strength approximates or exceeds the strength of many cast steels. Alloying, however, is usually necessary if strengths over 50,000 psi are required.

Other outstanding advantages that gray iron possesses include: 1) excellent damping capacity, 2) self-lubricating properties and the ability to retain a surface oil film under adverse conditions — with consequent high resistance to wear and seizure, 3) low notch sensitivity, 4) excellent machinability, 5) compressive strength approximately three times as great as tensile strength, 6) response to heat treatment comparable to that of eutectoid steel, 7) comparatively high resistance to tap water and other mildly corrosive media, and 8) a controllable modulus of elasticity that minimizes distortion during heating.

Engineering Properties

Tensile strength

This is considered to be one of the most important properties of gray iron and has been widely adopted as the basis for a working classification. The accompanying summary of specifications adopted by the ASTM and other specifying groups lists the classes of gray irons according to tensile and transverse strength. Tensile strength of the seven main classes (20 to 60) ranges from 20,000 to 60,000 psi. Most castings are specified as class 25, 30 or 35.

As shown in Fig 1, the tensile properties of gray iron are directly related to section thickness. Properties of a class 20 iron can vary from 13,000 to 40,000 psi, depending on the diameter of the section from which the test bar is taken. It is also evident that the properties of a class 30 iron can vary from those of a class 20 to those of a 50 iron, depending on section size.

Compressive strength

The compressive strength of gray iron (see Table 1) ranges from about 83,000 to 188,000 psi. These values are about three to four times the equivalent values of tensile strength. The ratio between compressive and tensile strength varies inversely as the tensile strength. Compressive strengths of gray irons are higher than those of most nonferrous alloys and the usual normalized cast steels, and are on a par with those of alloy steels that have not been heat treated.

Modulus of elasticity

The elastic modulus of gray iron varies from about 10 to 24 million psi (Table 1), depending on microstructure of the iron. A microstructure of fine graphite and pearlite favors the higher values. Typical stress-strain

TABLE 1—TYPICAL MECHANICAL PROPERTIES OF STANDARD GRAY IRONS

ASTM Class	Tensile Strength, psi	Compressive Strength, psi	Torsional Shear Strength, psi	Modulus of Elasticity, 10^6 psi		Reversed Bending Fatigue Limit, psi	Brinell Hardness
				Tension	Torsion		
20	22,000	83,000	26,000	9.6–14.0	3.9–5.6	10,000	156
25	26,000	97,000	32,000	11.5–14.8	4.6–6.0	11,500	174
30	31,000	109,000	40,000	13.0–16.4	5.2–6.6	14,000	201
35	36,500	124,000	48,500	14.5–17.2	5.8–6.9	16,000	212
40	42,500	140,000	57,000	16.0–20.0	6.4–7.8	18,500	217
50	52,500	164,000	73,000	18.8–22.8	7.2–8.0	21,500	228
60	62,500	187,500	88,500	20.4–23.5	7.8–8.5	24,500	252

curves are shown in Fig 2. Because gray iron does not follow Hooke's law exactly, the modulus in tension is usually determined arbitrarily as the slope of the line connecting the point of origin of the stress-strain curve with the point corresponding to 25% of the tensile strength. Occasionally the slope of the curve near the origin is used as the elastic modulus.

Torsional shear strength

As shown in Table 1, the torsional strength of gray iron is high. In many grades it is greater than for some grades of steel. This characteristic, plus its low notch sensitivity, makes gray iron—particularly in the higher tensile strength grades—a suitable material for various types of shafting. For the high strength irons, stress concentration factors associated with changes in section shape and thickness are important for torque loads as well as for tension loads.

Shear strength

The ratio between shear and tensile strength of gray irons varies from 1.0 to 1.6. The lower ratio applies to the high tensile strength irons and the higher ratio to the weaker irons.

Endurance limit

The endurance or fatigue strength of gray iron is about 35 to 50% of its tensile strength. The 35% value applies to very large sections and the 50% value to smaller sections. For most designs an endurance limit that is 40% of tensile strength can be used safely. Because gray iron is less sensitive to notches, it has as high an endurance limit in many applications as materials of substantially higher tensile strength.

Yield strength

Typical values for yield strength of gray irons are shown in Table 2. Yield point is not clearly defined, and yield strength is usually taken as the stress at the point of 0.2% elongation. Yield strength is generally about 85% of ultimate tensile strength.

Hardness

Brinell hardness measurements of gray iron are actually an average for the soft graphite and the metallic matrix. Variations in graphite size and distribution cause wide variations in hardness even though the hardness of the metallic matrix is constant. Hardness can be held within certain limits by controlling the method of manufacture, composition and rate of solidification.

From the values listed in Tables 1 and 2 it can be seen that indentation hardness increases proportionally with the tensile strength. Tensile strength and hardness are related approximately by the formula: T.S. = Bhn x K, where K = 160 to 210, depending on composition and microstructure of the iron.

Notch sensitivity

In general, little allowance is required for the strength reduction caused by notches or abrupt section changes of gray iron members. The lower strength irons exhibit only slight strength reductions in the presence of fillets and holes. Higher strength irons, however, exhibit greater reductions and the normal stress concentration factors (see "Metals Handbook, 1954 Supplement," p 97) should be used.

Impact strength

Gray iron is not recommended when high impact resistance is required. It has considerably lower impact strength than either cast carbon steel or malleable iron. It has been shown that the cast irons with the best impact

TABLE 2—YIELD STRENGTH OF GRAY CAST IRON

Type	Yield Strength, psi
Gray Cast Iron (as-cast)	
Class 20	22,000
Class 30	29,000
Class 50	45,000
Gray Cast Iron (heat treated for high strength)	
Class 30	45,000
Class 50	65,000
Spheroidal Graphitic Cast Iron	
Type 60-45-10	50,000
Type 80-60-03	65,000

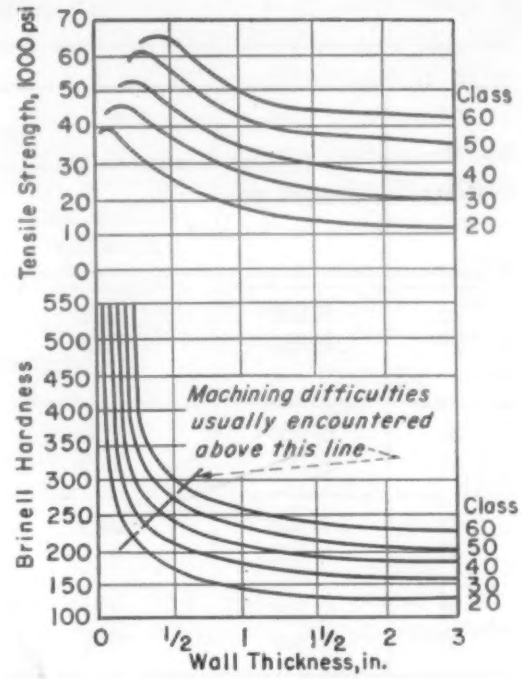


***Fig 1**—Variation of tensile strength and Brinell hardness with section thickness. Properties are for center of section.*

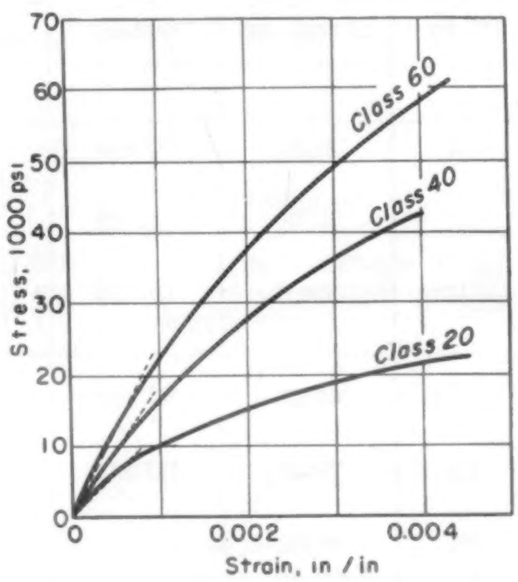


***Fig 2**—Representative stress-strain curves for class 20, 40 and 60 gray irons. Modulus is arbitrarily determined by slope of line connecting origin with the point corresponding to one-fourth of tensile strength.*

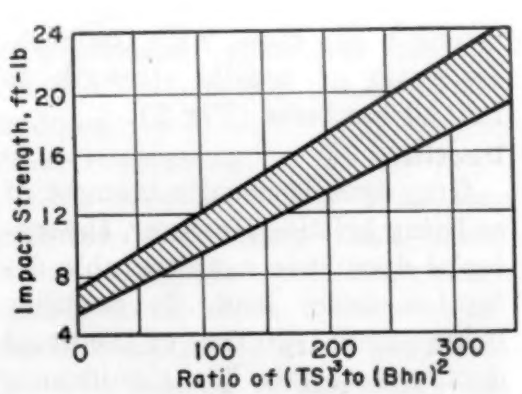


***Fig 3**—Relation of impact strength to the ratio of tensile strength to Brinell hardness (TS^3/Bhn^2).*

SUMMARY OF GRAY IRON SPECIFICATIONS

GENERAL CASTINGS[a]

Class	Min Tensile Strength, psi	Min Transverse Breaking Load, lb			Typical Applications
		0.875-in. bar, 12-in. span	1.2-in. bar 18-in. span	2.0-in. bar, 24-in. span	
20 25	20,000 25,000	900 1025	1800 2000	6000 6800	Lightweight and thin sections requiring good appearance, high machinability and close dimensions. Minimum tensile requirements
30 35	30,000 35,000	1150 1275	2200 2400	7600 8300	General machinery, municipal and water works, light compressor bodies
40 45	40,000 45,000	1400 —	2600 —	9100 —	Machine tools, medium gear blanks, heavy compressors, motor blocks
50 60	50,000 60,000	1675 1925	3000 3400	10,300 12,500	Dies, high pressure cylinders, heavy duty machine tool parts, large gears, press frames

AUTOMOTIVE CASTINGS

SAE No.[b]	Min Tensile Strength, psi	Brinell Hardness	Transverse Properties (1.2-in. bar, 18-in. span)		Min Total Carbon Content, %	Typical Applications
			Min Breaking Load, lb	Min Deflec-ion, in.		
110	20,000	187 max	1800	0.15	—	Miscellaneous soft iron castings in which strength and microstructure are not a primary consideration
111	30,000	170–223	2200	0.20	—	Small cylinder blocks, heads, pistons, clutch plates and housings, oil pump bodies, gear boxes, lightweight brake drums
113[c]	30,000	179–229	2200	0.20	3.4	Brake drums and clutch plates for moderate service requirements where high-carbon iron is desired and heat checking is a problem
114[d]	40,000	207–269	2600	0.27	3.4	Heavy duty drums and clutch plates where both strength and resistance to heat checking are definite requirements
120	35,000	187–241	2400	0.24	—	Automotive cylinder blocks, heads, flywheels, cylinder liners, pistons
121	40,000	202–255	2600	0.27	—	Truck and tractor cylinder blocks, heads, heavy flywheels, tractor transmission cases, differential carriers
122	45,000	217–269	2800	0.30	—	Diesel engine castings, liners, cylinders, pistons, and general heavy parts

strength are those with the highest ratio of tensile strength to Brinell hardness (Fig 3).

Ductility

Gray iron is usually thought of as being brittle. However, the material does have a measurable deflection under load, its ductility being about 1/30 that of the usual ductile materials. The significance of ductility in many designs has been exaggerated. The elongation usually measured is the maximum reached just before tensile failure and is quite unrealistic. Elongation at the yield point (less than 1% for mild steel) is more significant.

In many designs the usefulness of a structure is limited primarily by its allowable deflection before rupture. If this deflection is exceeded the part is just as useless as though a tensile failure had occurred. Because of its low ductility, cast iron is well suited for use in parts where low elongation combined with adequate strength is needed.

Cast iron's lack of ductility does not permit equalization of stresses under overloads. For example, when two ductile members are bolted together on faces which are not exactly flat, plastic deformation can take place until the faces are in complete contact. A redistribution of stress occurs and the members continue to function ef-

PRESSURE CONTAINING CASTINGS FOR USE AT 450 TO 650 F[e]

Class	Min Tensile Strength, psi	Chemical Composition, %	Typical Applications
40 50 60	40,000 50,000 60,000	Carbon equivalent[f] 3.8 max; phosphorus 0.25 max; sulfur 0.12 max	Valve bodies, paper mill drier rolls, chemical process equipment

PRESSURELESS CASTINGS FOR USE AT HIGH TEMPERATURES[g]

Type	Properties	Chemical Composition, %[h]				Typical Applications
		C equiv.	C min	P max	S max	
I	Superior thermal shock resistance. Deliberately soft, low strength	3.81–4.40	3.50	0.60	0.12	Stoker and fire box parts, grate bars, process furnace parts, ingot molds, glass molds, caustic pots, metal melting pots
II	Average thermal shock resistance and moderate strength (above 30,000 psi tensile strength may be expected)	3.51–4.10	3.20	0.60	0.12	
III	High strength at elevated temperatures. Up to 40,000 psi room temperature tensile strength	3.20–3.80	2.80	0.60	0.12	

HIGH ALLOY SCALE-RESISTANT CASTINGS

Type	Min Tensile Strength, psi	Brinell Hardness	Chemical Composition, %								Applications
			Total C	Si	Mn	Ni	Cr	Cu	S	P	
Navy Spec. 46-1-9	25,000	120–180	2.60–3.00	1.25–2.20	0.80–1.30	12.0–15.0	2.00–3.50	5.0–7.0	0.10 max	0.20 max	For resistance to corrosion of acid, caustic and salt solutions, including concentrated brine

[a]Applicable specifications: ASTM—A48-56, ASA—G25.1-1943, ASME—S61-1948, AASHO—M105-49, CSA—S61-1948, Federal—QQ-1-652a

[b]Other applicable specifications: ASTM, A 159-55.

[c]Graphite shall be type A, size 2 to 4 (ASTM A-247). Matrix shall be lamellar pearlite. Ferrite, if present, shall not exceed 15%.

[d]Graphite shall be type A, size 3 to 5 (ASTM A-247). Matrix shall be of fine lamellar pearlite, with cementite, free ferrite, or both not to exceed 5%.

[e]ASTM A 278-56 [f]Carbon equivalent (C.E.) = % C + 0.3 (% Si + % P)

[g]ASTM A 319-53 [h]Chromium, if required, may be designated as a range as follows: Type A—0.20-0.40% Cr; B—0.41-0.65% Cr; C—0.66-0.95% Cr; D—0.96-1.20% Cr.

fectively. If cast iron were used under the same conditions, a failure would be liable to occur.

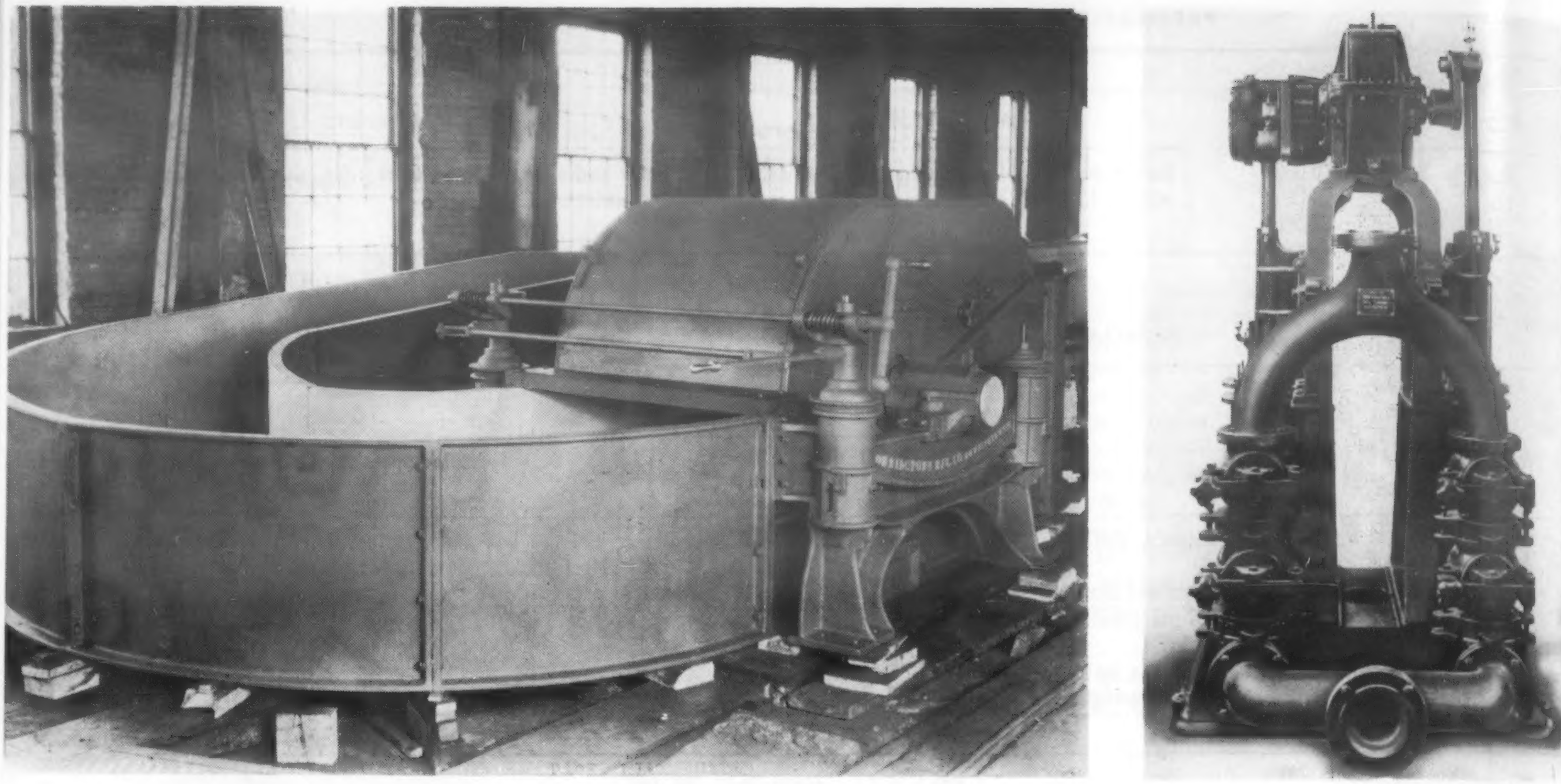
Damping capacity

Damping capacity is defined as the amount of work dissipated as heat by a unit volume of material during a completely reversed cycle of unit stress. It indicates the ability of the material to absorb or dampen vibration. Gray cast iron possesses outstanding damping properties and assists markedly in producing smoothness of operation in internal combustion engines, machine tool frames and other structures where vibration is encountered.

Relative damping capacities of two classes of gray iron and low carbon steel are shown in Fig 4. It is significant to note that damping capacity varies inversely with modulus of elasticity. This factor is particularly important in the design of crankshafts, where severe torsional vibrations can be avoided by selecting the optimum modulus.

Wear resistance

Gray iron is widely used for machine components that must resist wear. Its excellent wear resistance is often attributed to the lubricating effect of graphite flakes scattered throughout the iron. For best operation lubrication should be provided; however, gray iron can be used with mar-



Downington Mfg. Co.

***Paper mill beater** and stock pump are constructed largely from gray iron castings.*

ginal lubrication in applications where many other materials would fail.

In applications such as valve guides, latheways and sliding members, satisfactory wear resistance is obtained with properly specified and controlled as-cast gray iron. Hardened iron is used to obtain maximum wear resistance in severe applications such as cylinder sleeves for high speed diesel engines, camshafts, gears and similar heavily loaded parts.

Corrosion resistance

Although it is not generally classified as a corrosion resistant material, unalloyed gray iron normally offers better resistance to corrosion than many other general purpose ferrous materials. Ordinary cast iron rusts quite readily under atmospheric conditions. This rust, however, forms a relatively adherent protective coating which offers fairly good resistance to atmospheric and soil corrosion, acids and alkalies. Some cast iron water mains and gas lines have served for more than 100 years.

Heat resistance

In most cases cast irons suffer a permanent loss of strength at elevated temperatures. Strong, close-grained irons minimize strength loss at high temperatures, but alloys should be used for maximum strength retention (see "Try Gray Irons for High Temperature Service," M&M, Feb '55 p 90). All irons exhibit a very slight change from their room temperature tensile strength at temperatures up to 600 F. Irons designed for use at elevated temperatures can carry full design loads up to 800 F. Above 900 F, tensile strength takes a sharp drop and keeps decreasing as temperature rises.

In common with other ferrous materials, gray iron is likely to oxidize at high temperatures, particularly in the presence of some corrosive media. Ordinary irons also tend to increase in volume at high temperatures, particularly when they are subjected to repeated thermal cycling. This growth causes a serious loss in strength and an increase in brittleness. Growth rarely occurs at temperatures below 600 to 700 F unless certain corroding agents such as superheated steam are present. In the soft, coarse-grained types growth and consequent loss of strength can occur above 650 F. Growth can be avoided by selection of the proper grade of iron and by heat treatment prior to final machining.

Low temperature properties

Gray iron castings retain their properties down to extremely low temperatures. Tests have been carried out as low as −317 F. In

TABLE 3—MACHINABILITY OF GRAY IRON

Microstructure	ASTM Class	Tensile Strength, psi	Brinell Hardness	Cutting Speed[a] fpm
Acicular iron	50	59,000	263	150
Fine pearlite, alloy	40	45,000	225	310
Ferrite (annealed)	—	15,700	100	960
Coarse pearlite, no alloy	35	35,000	195	325

[a]Cutting speed to produce 0.030-in. wear land on single-point carbide tool as the result of removing 200 cu in. of metal. (U.S. Air Force Machinability Report, vol 1, 1950, p 135).

some cases tensile strength and hardness showed a slight increase, but there was no increase in brittleness. Below −112 F a slight decrease in impact resistance was exhibited. All in all, gray iron is relatively stable over a temperature range of 1100 deg —from about -300 to 800 F.

Machinability

Machinability of gray iron is considered superior to that of virtually all grades of steel, its superiority being attributable to its graphite content. Ease of machining is usually inversely proportional to the tensile strength of the iron (see Table 3). These data serve as an approximate quantitative evaluation but not as a quantitative index. Optimum cutting feeds, speeds and finish requirements must be studied for each individual application.

Machinability can often be improved by annealing. Annealing is usually of the subcritical type, such as 1 hr at 1350-1400 F, or heating to 1450-1500 F and cooling at 40 deg per hr to 1100 F. These treatments produce lower hardness and strength. For example, a typical class 35 iron can be downgraded to about class 20 after annealing. Gray iron should not be annealed when wear resistance is required.

Density

The density of gray irons at room temperature varies from about 0.25 lb per cu in. for open-grained, high-carbon irons to 0.27 lb per cu in. for close-grained, low-carbon irons. The density of liquid cast irons just above the final solidification temperature is about 0.23 lb per cu in.

Coefficient of expansion

An expansion coefficient of 5.6 x 10^{-6} in. per in. per deg F is accurate enough for calculations involving ordinary temperature changes at or near room temperature. Expansion varies somewhat with the type of iron and is greater in the softer and higher-carbon irons.

In the range from room temperature to 1058 F the expansion coefficient of gray iron varies

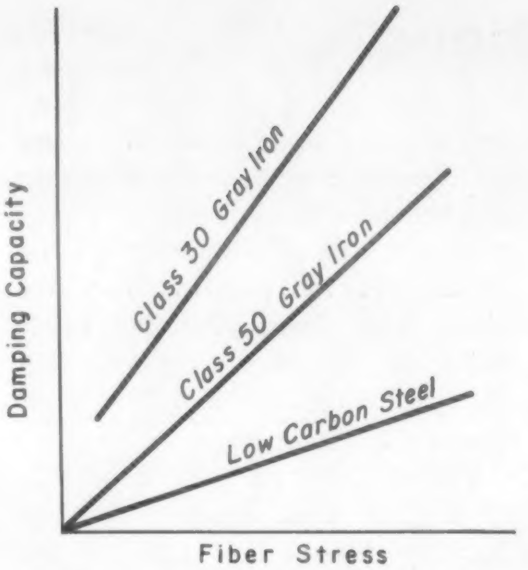


Fig 4—*Relative damping capacity of two classes of gray iron and a low carbon steel. Damping capacity is an inverse function of elastic modulus.*

from 5.1 to 9.4 x 10^{-6} in. per in. per deg F.

The average coefficient of expansion is about 7.2 x 10^{-6} in. per in. per deg F in the range of 32 to 932 F and about 5.8 x 10^{-6} in. per in. per deg F in the range of 32 to 212 F.

Shrinkage

Ordinarily, ⅛ in. per ft (1%) is allowed for the linear contraction of gray iron. This allowance is often inaccurate in practice, and a more precise evaluation of the effects of mass, composition, shape, mold and core may be required. Contraction usually decreases with an increase in mass and increases with an increase in tensile strength.

Thermal conductivity

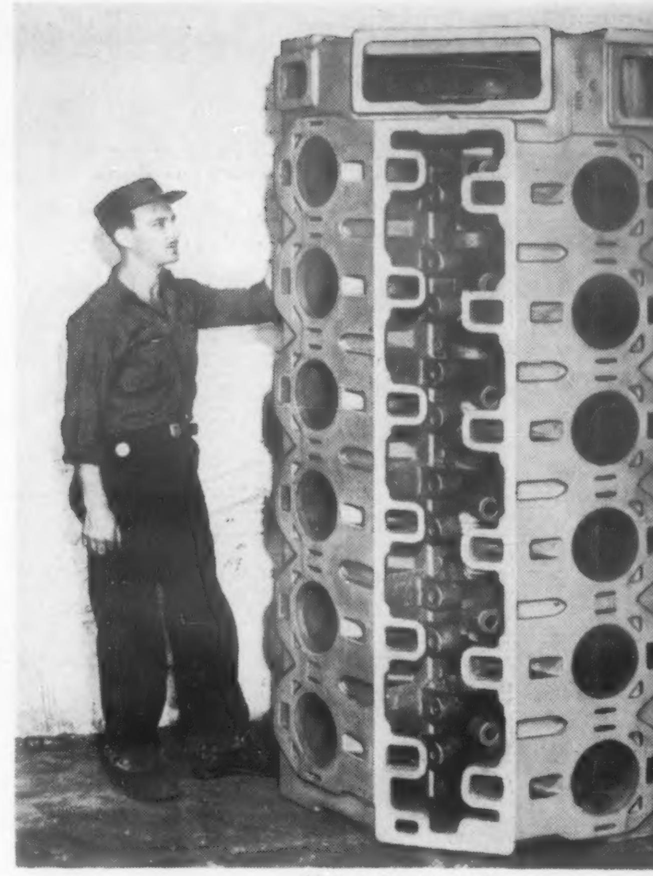
The thermal conductivity of gray iron varies from 290 to 406 Btu/sq ft/in./hr/deg F.

Specific heat

The specific heat of gray iron is about 0.131 at 212 F. This value changes slightly as the temperature increases, and also changes with the type of iron, but it is sufficiently accurate for most calculations.

Electrical, magnetic properties

Primarily because of its silicon content the resistivity of gray iron is relatively high compared to that of other ferrous metals. Resistivity is increased by increasing the total carbon and silicon content.



Motor Castings Co.

Wide size range *of parts used in internal combustion engines is indicated by carburetor throttle body (bottom) and crankcase for 12-cylinder oil field engine (top).*

Magnetic properties vary widely. Some gray irons with low permeability and high coercive force are suitable for permanent magnets. Others with high permeability, low coercive force and low hysteresis loss are suitable for electrical machinery.

The highest magnetic induction and permeability are found in annealed white irons, such as malleable cast iron. Flake graphite such as that contained in gray iron does not affect hysteresis loss but prevents the attainment of high magnetic induction.

Design Considerations

Sizes and tolerances

Typical tolerances for various sizes of gray iron sand castings are given in Table 4. Closer tolerances can of course be obtained by special casting techniques. Tolerances on shell moldings can be kept as low as ± 0.005 in. per in. Tolerances on parts produced by the lost wax or frozen mercury processes are also usually quoted as ±0.005 in. per in., but are often held closer. Similar tolerances can be met on permanent mold castings of simple shape.

TABLE 4—AS-CAST TOLERANCES

Size of Casting	Tolerance	Added Machining Allow., per face
Up to 8 in.	±1/16 in.	1/8 in.
8 to 18 in.	±1/8 in.	3/16 in.
18 to 30 in.	±3/16 in.	5/16 in.
Above 30 in.	±1/4 in.	3/8 to 1/2 in.

TABLE 5—RECOMMENDED CASTING SECTIONS

ASTM Class	Min Section, in.	Min Volume/Area Ratio[a]
20	1/8	0.061
25	1/4	0.120
30	3/8	0.174
35	3/8	0.174
40	5/8	0.277
50	3/4	0.326
60	1	0.416

[a]Ratios are for square plates.

Section thickness

The minimum section thickness of a gray iron casting depends more on the cooling rate of the metal than it does on metal fluidity. Casting geometry, therefore, plays an important role in metal specification. As an example, the ASM Committee on Gray Iron states that although a 12 x 12 x 1/4 in. plate can be poured in both class 25 and 50 gray irons, the latter casting would not be gray iron because the cooling rate is so rapid that massive carbides are formed. On the other hand, it would be possible to cast class 50 metal in a diesel engine cylinder head containing 1/4-in. wall sections. The reason is that the section cooling rates are reduced by the mass effect of the enclosed cores and the close proximity of the 1/4-in. walls.

An evaluation of the size and shape of the casting as related to its cooling rate, or volume/area ratio, must be made before selecting a suitable grade of gray iron. Minimum recommended section thicknesses and V/A (volume/area) ratios for the various grades are shown in Table 5. Thinner sections than these can be produced, but foundry difficulties and cost will be minimized if the suggested thickness limits are observed.

Although sections of wide thickness variation can be cast, production can be facilitated by connecting sections with generous tapers (Fig 5). Thickness variations in ratios up to 4 to 1 are easily accommodated. Higher ratios can be used provided that property requirements are not too severe and alloying is permissible.

Fillet radii should be approximately equal to one-half the average section thickness and should be no less than 1/4 in. Some compromise, however, is sometimes necessary. Large radii promote lower stress concentrations, streamline flow of molten metal and easier pattern withdrawal. However, since the severity of shrinkage is a function of the diameter of the circle inscribed in the section (Fig 6), isolated metal concentrations in Y, T or X shaped sections can be avoided by using smaller fillets.

Care should be exercised at points where an exposed, critical face is backed up by ribs or bosses. If a projection is very large compared to the face thickness, a casting hollow may be produced on the face opposite the projection. This effect can be minimized by casting in a slight padding on the face side and subsequently machining off the excess metal. If appearance is the only consideration, a decorative pattern can be used to hide a depression in a face.

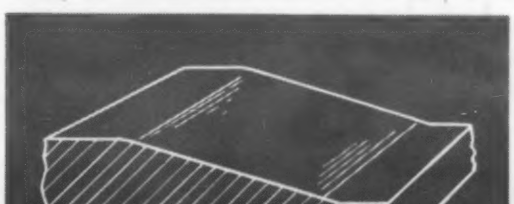


Fig 5—*Generous tapers should connect sections of different thickness wherever possible.*

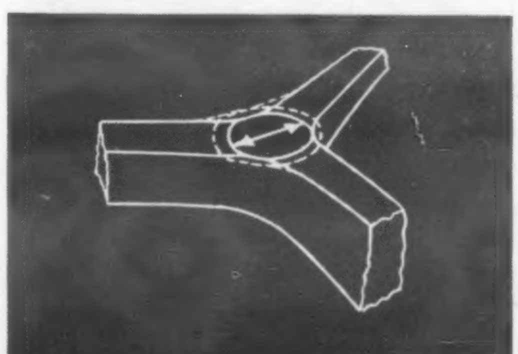
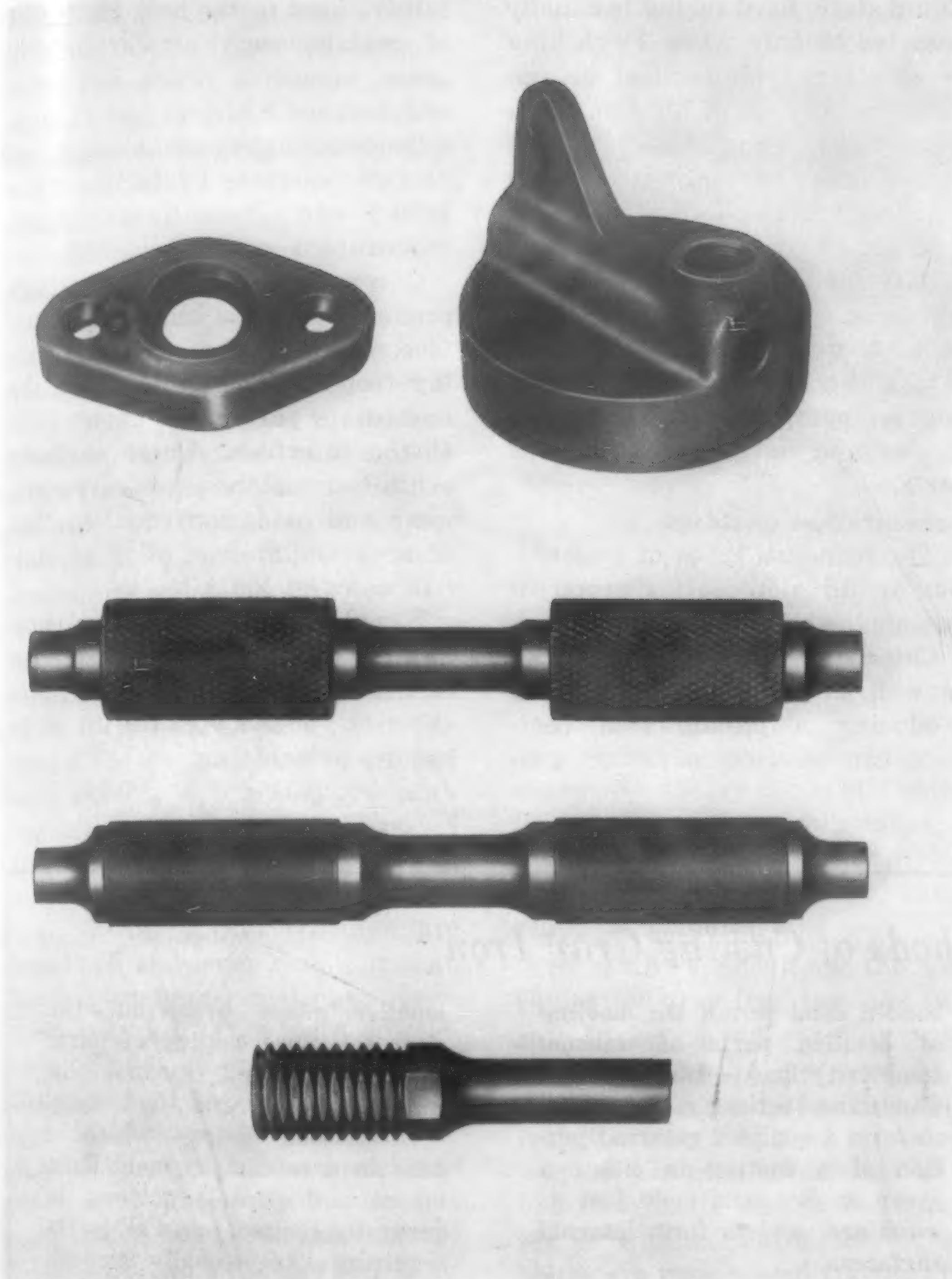


Fig 6—*Smaller fillets prevent isolated metal concentrations in Y, T and X sections and minimize severity of shrinkage.*



Black oxide coating *on gray iron castings possesses good wear resistance, can be used for decorative purposes, and forms a good bond for paint.*

Coatings and Finishes

Sprayed metal coatings

Practically every metal available in wire or powder form can be applied to gray iron. These coatings have produced substantial improvements in the wear resistance of bearings, shafts, packing surfaces and other mechanical parts. A small amount of oxide and some voids are present in all sprayed coatings. Ordinarily, these voids help to increase the wear resistance of lubricated parts. When the surface must resist penetration of corrosive fluids, however, a heavier than normal coating may be required. Because of their porosity, sprayed coatings exhibit low tensile strength and impact resistance.

Hot dip coatings

All four of the principal hot dip coating processes are applicable to gray iron.

Tinning produces surfaces with high resistance to atmospheric corrosion and attack by various foodstuffs. Tin coatings also facilitate assembly by soldering and sweating and are quite effective in bonding metals to a gray iron or steel base. For these reasons, tinned castings are used in a variety of applications, including bearing shells for engines and generators, parts of soldered assemblies, and operating parts and containers in food processing equipment. Wide composition limits—up to 3.5% total carbon, 2.7% silicon and 1.0% silicon and 1.0% phosphorus—do not have any appreciable effect on tinning qualities. Several proprietary methods of preparing the machined surface of castings for tinning have been widely adopted. Of these, the Kolene process is probably the most commonly used.

Galvanizing (zinc coating) is effective in increasing the corrosion resistance of castings to ordinary and industrial atmospheres, salt air, and saline, alkaline and other corrosive water solutions. Additional advantages include low cost, good adherence and easy application in heavy layers. Because of their immunity to corrosion, galvanized gray iron castings are widely used for sumps; dish washer, humidifier and refrigerator parts; sewer gratings; pole-line hardware and other assemblies.

Lead coating is also suitable where high resistance to corrosive atmospheres is essential but wear resistance is not required. Typical applications are pole-line and electrical hardware and farm and military equipment. Lead coatings are also resistant to sulfuric and sulfurous acid fumes, and they supplement the tendency of gray iron to resist concentrated sulfuric acid. They also provide an excellent base for painted coatings. Some limitations of lead coatings on iron include: 1) lack of a pure bond with iron, 2) tendency toward pinhole formation, 3) low resistance to wear and abrasion, 4) formation of unsightly corrosion products, and 5) poor corrosion protection if the coating is not complete.

Aluminizing (aluminum coating) enhances the resistance of gray iron to both corrosion and high temperatures. The adherent coating resulting from the sur-

face alloying between iron and aluminum greatly increases the resistance of castings to high temperatures and practically eliminates scaling up to 1650 F. For this reason aluminum coated castings are of potential value as oven liners, engine manifolds, muffles, heat reflectors, heating element holders and other parts where resistance to scaling or maintenance of a heat reflecting surface is required.

Hard facings

Hard facing is particularly valuable for castings that require a heavy adherent surface armor (1/8 in. or over) that is resistant to impact or corrosion as well as wear. Since gray iron can be given a hard, chilled layer of wear resistant iron carbides simply by rapid cooling from the liquid state, hard facing is usually resorted to only when 1) chilling is considered impractical or impossible because of design, 2) a worn part is being built up, or 3) a special order of wear or corrosion resistance is required.

Typical castings that have been satisfactorily hard faced by either gas or arc welding are crushing rolls, large blades used to mix sand and cement, pulverizer disks, augers, pump castings, conveyor screws and agricultural machine parts.

Cementation coatings

The principal types of cementation or diffusion coating processes are applicable to gray iron.

Calorizing (aluminum coating), as well as the other methods of producing aluminum-rich coatings, can be used to protect containers used in the heat treatment of metals, such as carburizing boxes, annealing boxes, and trays and furnace fittings; and in miscellaneous applications such as heat exchangers. Protection up to 1400 F and substantial resistance to sulfurous gases is claimed.

Chromizing (chromium coating) produces a high chromium surface, the chromium content ranging from about 35 to 70% at the immediate surface to about 13% at the interface. These surfaces exhibit resistance to corrosion, wear and oxidation equal to that of a chromium-iron alloy of similar composition.

Sheradizing (zinc coating) produces a uniform coating of zinc or iron-zinc alloy. Threaded parts show no tendency to fill up as in hot dip galvanizing.

Methods of Casting Gray Iron

Green sand casting is the most commonly used and generally the least expensive method used for the molding of small and medium size castings. The term green denotes the presence of moisture in the refractory molding sand.

Dry sand casting is used extensively for the production of large and very heavy castings. Mold surfaces are coated with a moist refractory and dried before pouring to increase the strength of the mold and provide resistance to large masses of metal.

Shell mold casting is done in resin-impregnated baked sand molds and is usually limited to small and medium-small castings. It provides improved accuracy, detail and finish. Mechanical properties of shell molded castings are comparable to those of sand castings. Because of high pattern costs the process is usually limited to quantity production.

Core mold casting utilizes the type of sand commonly used for cores. The free flowing characteristics of the baked organic bonded sand permit the molding of detailed parts of unusual complexity and section thinness. Core sand sections may be used to form a complex external portion of a casting in either a green or dry sand mold just as cores are used to form internal surfaces.

Permanent mold casting utilizes molds of metal or refractory materials. Because of rapid metal cooling castings made in metal molds are generally finer in grain than sand castings. Parts can be produced in large numbers and are generally limited to less than 25 lb in weight and 3/16 in. in section thickness. Coring is accomplished with conventional sand cores. Machining is facilitated because of better surfaces, and mold cost per casting is lower than in sand molding for certain castings in large quantities.

Ceramic mold casting is used for highly specialized parts where unusually high finish, fine detail and low tolerances are required. Molds are made from fired ceramics and are often assembled from a number of smaller pieces to permit the close tolerance casting of parts several hundred pounds in weight and several feet long.

Investment casting, which is done in a refractory mold built up on a disposable pattern, is generally limited to small parts requiring exceptionally smooth finish, fine detail and close tolerances. No consideration of draft or parting line is required since the pattern is melted out of the mold.

Centrifugal casting is usually used to produce a cavity in a casting without the use of a core. The metal is poured while the mold is rotated rapidly, thus throwing the metal to the inner mold surface by centrifugal force. Centrifugal force may also be used as a means of forcing metal into a mold. This method is often used in pouring small detailed castings in ceramic molds when the high surface tension of the molten metal and the low permeability of the mold material do not permit complete filling of the mold by gravity alone.

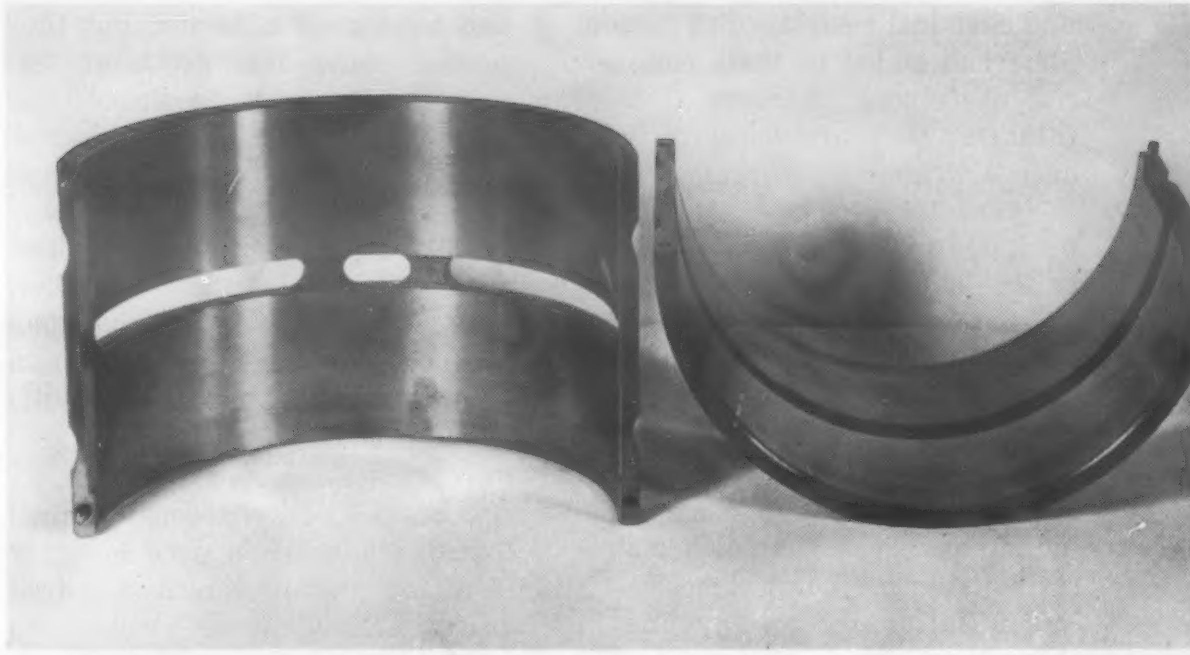
Electroplates

Along with improved appearance, excellent corrosion resistance, durability and hardness can be imparted to gray iron by thin electrodeposited coatings. Typical coating metals include nickel, chromium, cadmium, zinc, copper, tin, lead and their alloys.

Nickel plates used on gray iron fall into two general classes—the heavy, wear and corrosion resistant "hard" plates and the various thinner decorative plates with more limited corrosion resistance. Because of their toughness and resistance to wear and corrosion, heavy nickel plates are widely used on gray iron castings for food processing and railroad equipment, paper and textile mill rolls, filter plates, valves, etc. Deposits can be machined or ground and exhibit a tendency to work harden in service. Toughness of the coatings minimizes danger of plate lifting, cracking or blistering. Heavy nickel coatings are less hard and wear resistant than hard chromium coatings; however, they are often more practicable because of the higher throwing power of the plating solution and the greater rate of deposition. When very high hardness and wear resistance are required a thin layer of chromium (about 0.003 in.) can be deposited after a build-up with nickel.

Chromium plates are of three general types—thin, heavy and porous. A thin (about 0.02 mil) plate is almost invariably applied over previously deposited layers of copper and nickel, or nickel alone. It reproduces exactly the surface on which it is plated. The resulting finish is comparatively hard, lustrous, attractive and will not tarnish.

A heavier or so-called hard chromium deposit is commonly applied without intervening copper or nickel undercoats. The coating is extremely hard (Brinell 1000 to 1025) and possesses a low coefficient of friction and high resistance to seizure. In sufficient thicknesses it also provides high resistance to atmospheric corrosion and common industrial reagents (hydrochloric and sulfuric acids excepted). Heavy chromium plates are widely used for rolls in paper machinery, dies for forming plastics, linings for bushings, rams, plungers, spindles, etc.



Babbitted gray iron *bearing shell is used in main bearing of diesel engine.*

In many applications the usefulness of gray iron castings subject to severe or exacting wear conditions can be increased by a porous chromium plate. This plate is deliberately designed to contain pits or channels which serve to hold lubricants and prevent seizing or galling. Porous chromium plates are widely used for the protection of automotive and diesel engine cylinders, and the process is gradually spreading to other castings, such as those for compressors, hydraulic equipment and special rolls.

Cadmium plates are more widely used on gray iron than zinc plates and offer better protection to alkali attack and marine atmospheres. They are also preferable on castings that are threaded or operate with close tolerances, since the unsightly and bulky white corrosion products of zinc interfere with machine action and make it difficult to remove parts for inspection or replacement. Cadmium is more expensive than zinc and is used mainly for: 1) indoor applications where only a thin coating is necessary, 2) parts for which zinc coatings are definitely unsuitable (such as machine tool parts), and 3) an undercoat for zinc.

Zinc plates are sometimes used for gray iron parts used in rural atmospheres, and where corrosion resistance or attractive appearance, rather than wear resistance, is a critical design factor. The coating is not widely used, however, because of the difficulty in plating zinc directly on gray iron from the cyanide bath.

Organic finishes

Organic finishes are used for both corrosion protection and appearance.

Oleoresinous or varnish base paints are the oldest, slowest drying and least expensive organic finishes used on gray iron. High solids content permits deposition of heavy films, but color retention under heat, chemical resistance and film quality are only fair. Although oleoresinous finishes are still in use there has been a rapid trend to convert to the more rapid drying or synthetic finishes.

Lacquers are the fastest drying of air-dry finishes, may be force-dried up to 180 F, and are used where finishing speed is of prime importance. Because of their drying speed, they are particularly suitable as sealers to protect castings during shipping or outdoor storage. In recent years, improvement in the toughness, durability

and chemical resistance of lacquer films has added to their commercial usefulness. Because of their thinness, they are normally used over a primer and/or filler.

Synthetic resin paints are intermediate in air-drying rate between oleoresinous and lacquer finishes. They can be baked at comparatively high temperatures (usually 200 to 350 F) and consequently lend themselves to fast production schedules. In general, they are tougher and more resistant to chemicals than either oleoresinous or lacquer finishes.

The suitability of any one of these three types of organic finishes cannot always be firmly established. Combinations of any two may often be better for a specific job than one alone.

Special one-coat and two-coat texture finishes for gray iron provide an attractive appearance and often eliminate the need for an expensive finishing system that includes extensive filling, smoothing and sealing operations. *Wrinkle finishes* derive their texture from the contraction of the upper layers of the sprayed paint into ridges during drying. The resulting finish is economical, attractive and durable and can be varied in texture from very fine (suede) to very coarse (pine tree) patterns. *Hammered finishes* derive their appearance from metallic powders, usually aluminum, suspended in the paint. Finishes can be applied in one spraying and have good adhesion, but they possess much less depth of texture than wrinkle finishes. They can be either air-dried or baked. *Spatter finishes* consist of a base coat over which a layer of heavily textured spatter has been applied. The finish is usually thicker, tougher and more protective than either a one-coat wrinkle or a hammered finish. For best results the film should be baked.

Porcelain enamels

Porcelain or vitreous enamel coatings have been used on gray iron for more than a hundred years. Excellent adherence to sandblasted surfaces, high chemical resistance and extreme hardness and scratch resistance have been factors in their popularity.

Acid resistant enamels are available that resist all common acids except hydrofluoric. Resistance to alkalies, though not as great, is sufficient for many applications. Because of their refractory base, they can be used at high temperatures (600 to 1000 F) without discoloring or heat cracking. They can also withstand rapid temperature changes.

Chemical conversion coatings

Conversion coatings have proved quite valuable for many special applications because of their attractive appearance, wear and heat resistance, and ability to promote a bond with organic coatings.

Phosphate coatings are chemically inert, protect surfaces from atmospheric corrosion, provide an excellent paint base, and help to prevent seizing of parts during break-in periods. Three types of coatings are available.

The first type is a light, highly absorbent coating. It provides a close bond between a paint and the metal surface and also prevents corrosion from spreading under the paint if the protective film is accidentally ruptured.

The second type is a thicker coating (0.3-0.5 mil) which, if followed by staining, oiling or waxing, provides good protection and an attractive finish. Although the coating does not provide substantial protection against chemicals or highly corrosive atmospheres, it is usually adequate for normal indoor exposure. It is also used on threaded parts.

The third type is a relatively thin coating (0.04-0.06 mil) which makes gray iron surfaces highly absorptive to oil or a suspension of colloidal graphite in oil. It permits rapid break-in of moving parts without scuffing, seizing or welding.

Black oxide coatings with high wear resistance can be produced for such applications as tappets and piston rings. The attractiveness of the finish, especially when oiled or waxed, makes it useful wherever decorative appearance without any great corrosion resistance is required. The coating is also a good base for organic finishes.

Heat Treatment

Stress relieving

To obtain maximum stress relief with minimum chance for decomposition of combined carbon, a temperature range of 950 to 1050 F is recommended for unalloyed gray iron. As shown in Fig 7, about 60 to 80% of all internal stresses can be removed by holding castings in this range for 1 hr. For low alloy gray iron, higher temperatures—of the order of 1050 to 1100 F—are advisable. For very high alloy irons, temperatures in the range of 1100 to 1200 F are required.

Annealing

The annealing process is applied to gray iron almost exclusively for promoting machinability. Annealing is far more effective in increasing machinability than the change from fine to coarse pearlite brought about by changes in chemical composition or casting section. In some tests the machinability of completely annealed gray iron was found to be 50 times greater than that of unannealed gray iron at a cutting speed of 300 fpm, and 8 times greater at 1100 fpm. Also, the power requirement was reduced to one-half to one-third of that before annealing.

Unfortunately, the annealing process may have deleterious effects on other casting properties. Annealing has a tendency to reduce the smoothness and brightness of gray iron surfaces. Tensile strength may be reduced 10

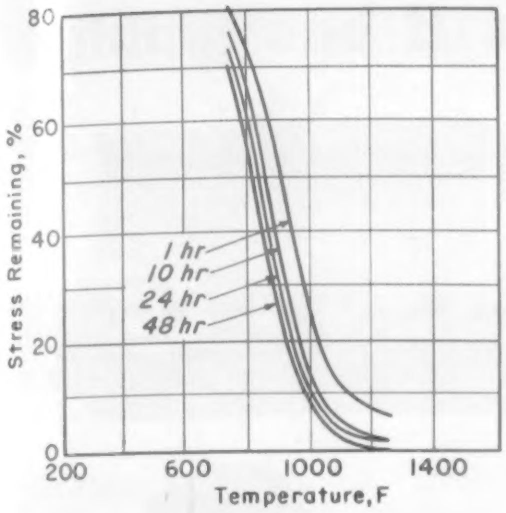


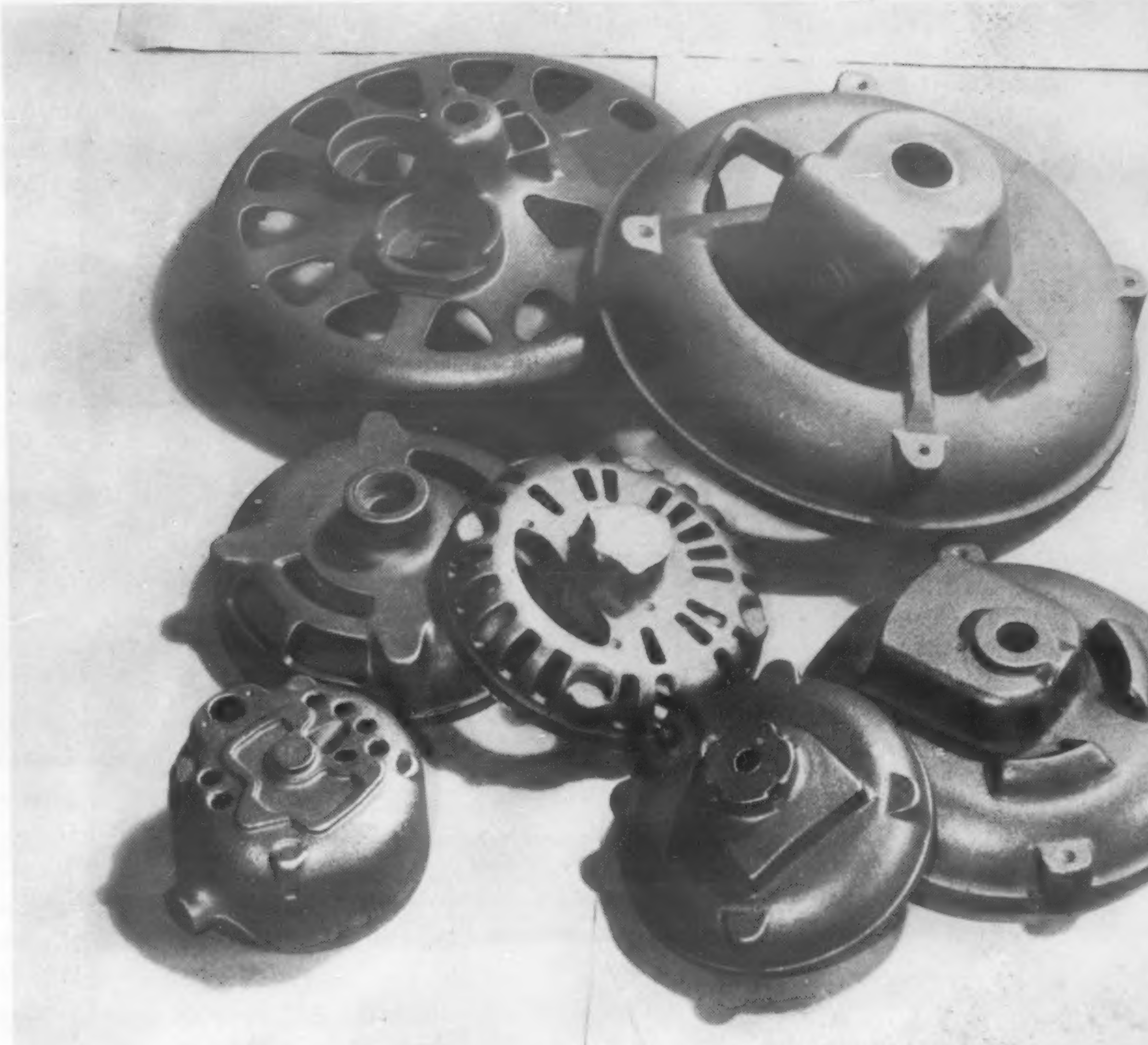
Fig 7—*Effect of holding time on stress relief of a typical gray iron. About 60 to 80% of internal stresses are removed by holding 1 hr at 950-1050 F.*

to 30% and hardness from 30 to 150 Brinell points due to the conversion of pearlite to ferrite plus graphite. Reduction in hardness is valuable as far as machinability is concerned, but may be accompanied by a corresponding decrease in the types of wear resistance that depend on surface hardness.

Flame hardening

Flame hardening is the most common type of surface hardening applied to both plain and alloy gray iron. In the process the outer layer of the casting is heated to a temperature above the transformation range (usually to a minimum of 1500 F) by an oxy-acetylene or similar flame, and then rapidly cooled to promote the formation of martensite. Thus, selective portions of the surface may be rendered hard and wear resistant while the major portion of the casting retains the advantageous shock resistance and machinability of gray iron.

Extra foundry stock should be allowed, particularly on light sections, to permit clean up after heating as well as machining in the event of warpage. Holes should preferably be countersunk and located at least 1/4 in. from any edges. Sudden changes from light to heavy sections in the flame hardened area should be avoided and sharp corners eliminated by generous fillets.



East St. Louis Castings Co.

Low cost, excellent machinability *and good damping capacity account for gray iron's wide use in electric motor end plates and bells.*

Flame hardened areas should be designed so that they may be heated uniformly to prevent variations in the depth of the hardened layer. Proximity of massive and thin sections should be avoided. Wall sections and ribs adjoining the hardened surface should be at least 1/2 in. thick. Uniformity of the hardened layer may also be affected by reentrant angles which cause heat to dissipate rapidly and salient angles which act as heat-concentrating spots. However, flame hardening is the only method by which reentrant angles, slots, etc., can be satisfactorily hardened.

Typical applications of flame hardened parts are automotive and textile machinery, bearing housings, compressors, diesel engines, machine tools and printing presses.

Induction hardening

Because of relatively high equipment cost, induction hardening is normally used only when a large number of castings are to be hardened. Principal advantages of the process are rapid operation and ready control by means of such variables as heating time, power input and frequency. It is extremely important that castings to be hardened have a combined carbon content of more than 0.5%, and iron containing finely divided graphite is preferable. Also, surfaces should be smooth and free from flaws.

Full hardness of induction hardened parts is between 50 and 60 Rockwell C. Induction hardening to a reasonable depth, e.g., 0.1 in. for an 0.8-in. cylindrical bar or 0.2 in. for a 1.2-in. bar, has no adverse effect on strength properties. Greater depth, however, may reduce strength.

Distortion is less than that caused by quench hardening for similar properties. Maximum warpage in a 22-in. bar in one case was found to be 0.0015 in. after induction hardening com-

Cleveland Co-operative Stove Co.

***Heating equipment** parts made from gray iron include large variety of stove castings.*

pared to 0.007 to 0.01 in. after salt bath hardening. Distortion in thin-walled cylinders is not serious unless the hardened layer thickness exceeds 20% of total wall thickness.

Typical applications of induction hardened parts are bushings, cam followers, crankshafts, gears, cylinder bores, grinder rings and cutters, machine tool parts and pump bodies.

Quench hardening

Quench hardening differs from the surface hardening treatments previously decribed in that rate of cooling can be controlled to determine the final martensitic structure. Tempering of quenched gray iron is required and is usually accompanied by a loss in hardness and a gain in strength and toughness.

Gray irons that have been quenched and tempered usually possess wear resistance about five times as great as that of pearlitic gray iron. Tempering also improves the tensile strength of quench-hardened gray iron. Maximum strength in unalloyed castings is obtained by tempering in the range of 570 to 700 F. Temperatures of 750 to 930 F are necessary for alloyed irons.

Applications of quench-hardened gray iron have been numerous, particularly where high wear resistance combined with machinability and castability is required. Typical applications are cylinder liners, rolls for rubber processing equipment and printing presses, forging dies, gears, worms, shafts and electric motor frames.

Hot quenching

Hot quenching or isothermal heat treatment of gray iron is accomplished by quenching castings from a temperature above the critical range into a hot bath of salt, oil or molten lead. Ordinarily the casting is heated to 1500 to 1700 F, then quenched into a salt bath at temperatures from 450 to 850 F. Hardness, wear resistance and toughness are determined by holding time in the bath. Principal advantage of hot quenching is that the stresses set up are much less drastic than those set up by conventional quenching to room temperature.

Welding and Brazing

Oxyacetylene welding

Gas welding is generally the preferred method of joining gray iron. Heat input can be closely controlled during oxyacetylene welding, and by careful torch manipulation the metal can be kept within a fairly narrow temperature range, thus minimizing the danger of superheating and consequent metal run-off. Ordinarily, a minimum of auxiliary equipment is required since the torch may in many cases be used to preheat and postheat the weld. However, the process is somewhat slower than arc welding and may involve greater labor costs.

Oxyacetylene welding with a gray iron welding rod insures a deposit of the same color, composition and structure as the base metal. If properly made the bond will be as strong as the original casting. The process is less expensive than braze welding (see below) and, unlike braze welding, can be applied to castings which are to be enameled.

Oxyacetylene *braze welding* utilizing a bronze or copper-zinc filler rod is often the most satisfactory welding process in applications where a strong, dependable weld is required, where time is important, or where a large casting cannot be preheated successfully. Tensile strength of the weld metal ranges from 55,000 to 70,000 psi at temperatures up to about 500 F. Badly oil soaked or oxidized castings are often difficult to braze weld, however, and cleaning must be more thorough than for other welding methods. Color matching is difficult and it is impossible to enamel braze welds.

Arc welding

Since only a limited area is heated to high temperatures during arc welding, it is often unnecessary when using nonferrous or steel electrodes to preheat the entire casting to eliminate thermal stresses. Avoidance of the preheating step coupled with rapid metal deposition enables arc welds in large castings to be completed in comparatively short times. Also, arc welding can be performed in any position since the weld does not remain fluid for any appreciable length of time. Limitations, arising mainly from problems of temperature control and the creation of hard zones, make arc welding a supplement to, rather than a replacement for, gas welding.

The most widely used and generally successful arc welding is done with nickel-base electrodes, composed of pure nickel or an alloy of nickel and other metals, usually copper. Special nickel electrodes for nickel austenitic gray irons and for high phosphorous irons have also been developed. All of the above electrodes are suitable when a machinable weld is desired. Limitations do exist with nickel electrodes, however. Graphite, used in some flux coatings, may dissolve in the nickel and precipitate on cooling as an intergranular, interdendritic form which materially weakens the weld. The weld metal is also susceptible to cracking in thick sections.

Arc welds produced with mild steel electrodes are strong (especially if studded), produce a good color match and can be used before enameling or chromium plating. It is virtually impossible, however, to prevent the formation of a hard zone or layer at the junction of the weld metal and the base metal, and this type of welding should not be used where machinability is a factor. Furthermore, since the shrinkage of steel is greater than that of gray iron, high stresses can develop, producing cracking and preventing the formation of liquid-tight joints. Because of these limitations, arc welding with mild steel electrodes is usually confined to the repair of small pits and cracks and breaks in large castings that do not require machining.

Arc welding with a gray iron electrode has found a definite but limited use in the repair welding of gray iron. It is faster than oxyacetylene welding for the repair of small defects and can produce welds of comparable strength and machinability, although uniformity of results cannot be guaranteed.

Despite the fact that comparatively little cleaning or beveling is required and machinable welds with good color match can be produced, carbon arc welding with a

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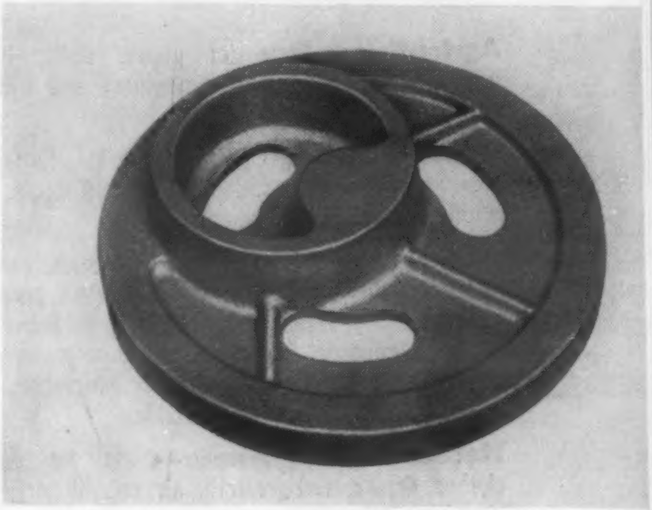
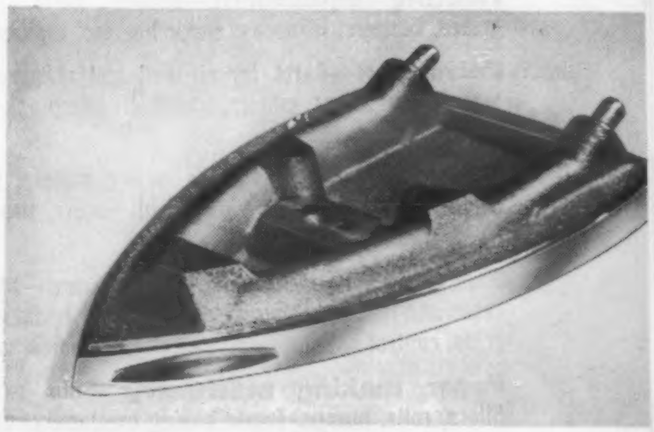


Eaton Mfg. Co.



Appliance parts *cast from gray iron include connecting rod for refrigerator compressor (top), washing machine gear blank (center), and sole plate for iron (bottom).*

WHERE AND WHY GRAY IRON CASTINGS ARE USED

Application	Main Reasons for Use[a]
Automotive and internal combustion engines—Cylinder heads and blocks, brake drums, manifolds, pistons, tooling dies, clutch plates, diesel engine bed plates; transmission, torque converter, crankcase and flywheel housings	Good as-cast finish, machinability, vibration absorption; resistance to wear, heat and corrosion; durability, wide strength range, rigidity, low notch sensitivity
Building and construction—Crane drums, counterweights, pumps, scraper shoes, earth moving equipment, concrete mixers, tampers, hoists, hardware, power tools, highway grates, culverts, manhole covers and frames	Wear and corrosion resistance, durability, machinability, wide strength range, rigidity
Utilities—Power plant and water works equipment, fuel and ash handling equipment, grates, pumps, valves, gas regulators	Good as-cast finish, wear and corrosion resistance, durability, wide strength range
Machine tools—Columns, beds, arms, saddles, head stocks, frames, knees, rams, cams and gears for lathes, milling machines, drills, grinders, shapers, screw machines	Good as-cast finish, wear resistance, durability, rigidity, vibration absorption, wide strength range, low notch sensitivity
Agriculture—Parts for plows, drills, harrows, mowers, pumps, harvesters, dairy equipment and tractors. Silo parts, grinding plates	Wear resistance, durability, machinability, wide strength range, low notch sensitivity
Steel plant equipment—Blast furnace stoves, coke oven and furnace parts, ingot molds and stools, rolls, crane cable drums, brake drums, wheels	Wear and heat resistance, durability, wide strength range, low notch sensitivity
General machinery—Gears, frames, columns, flywheels, sheaves, pulleys, cams, hydraulic cylinders, pistons, valves, arms, housings, rolls, sprockets, crossheads, guides. Also, bases for all kinds of industrial machinery including machinery for chemical processing, food processing, power generation, printing, metalworking, glass making, bottle making	Good as-cast finish, wear resistance, durability, vibration absorption, machinability, rigidity, wide strength range
Household appliances—Parts for sewing machines, clothes dryers, refrigerators, air conditioners, irons, washers, lawn mowers, electric motors	Good as-cast finish, wear resistance, durability, machinability, vibration absorption
Heating equipment—Stoker parts, boiler sections, grates, burners, furnaces, water heaters, radiator sections	Good as-cast finish, heat and corrosion resistance, durability
Petroleum—Parts for oil well and refinery equipment, gas station equipment, motors, filters, oil pump valves and housings, impellers, meters	Heat and corrosion resistance, durability, machinability, wide strength range
Municipal—Fire hydrants, water meters, incinerator parts, catch basins, manhole frames and covers, fire fighting pumps, water traps	Wear and corrosion resistance durability
Electrical and electric motors—Motor end bells, cases and frames, generator bases, stator bodies, electric controls, grids, control box housings, switchgear bodies, wiring boxes	Good as-cast finish, corrosion resistance, durability, vibration absorption, rigidity
Paper making machinery—Pulp and paper mills, fillers, rolls, pumps. Paper boxing machinery, valves and fittings	Good as-cast finish, wear and corrosion resistance, durability, vibration absorption, machinability, wide strength range, low notch sensitivity, rigidity
Plumbing—Pressure pipe and fittings, soil pipe, gas regulators, traps, strainers, domestic fixtures, gas cocks, meters and valves, pump valves	Heat and corrosion resistance, durability, wide strength range, rigidity

[a]In most of the applications listed the excellent castability of gray iron is used to advantage.

gray iron filler rod is not widely used to weld gray iron. This neglect is due to the requirement for a high preheat, difficulties in handling the arc, and the extreme fluidity of gray iron at the high carbon arc temperatures.

Inert-gas-tungsten arc welding yields several advantages not obtainable in other forms of welding: no flux is required; little or no slag covering is exhibited, thus minimizing cleaning and grinding operations; and welds are free from blow holes. Application data, however, are not sufficient to provide final evaluation of its worth in competition with other welding processes. It is more rapid than oxyacetylene welding and most arc welding, but it may lack the flexibility and uniformity of results of oxyacetylene welding and the ease of application of arc welding.

Arc *braze welding* has been recommended in many applications involving the joining of large gray iron parts. The process is claimed to be fast, to be easy to apply, to require little heat input, and to produce welds with high tensile strength. However, the welds are generally considered inferior to gas welds made with gray iron or bronze rods, and they cannot be used where machinability and color match are required.

Brazing

Bonds produced by brazing with *silver alloys* are in many cases stronger than the parent metal. Flow point of the alloy is only 1100 to 1200 F, considerably below the temperatures that produce danger of hardening or of excessive stresses from uneven expansion. These bonds are not intended for high temperature service. Cost of the silver alloy is fairly high and it cannot be economically used to fill in large gaps or cavities. To achieve maximum bond strength, parts should have machined clearances between 0.0015 and 0.005 in.

Use of comparatively pure *copper* to join press fitted parts is limited. Phosphorous-copper alloys are unsuitable because of their tendency to form phosphides with ferrous metals. Some bronzes, e.g., a 6% tin-bronze with a melting point of 1700 F, have been successfully employed. Clearances are the same as for silver alloys.

Acknowledgement

The author gratefully acknowledges the fine help and cooperation extended by the Gray Iron Founders' Society, Inc., in supplying much of the basic data contained in this Manual.

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"Selection of Gray Cast Iron," prepared by the ASM Committee on Gray Iron, *Metal Progress*, Aug 15, 1955, pp 21-36.

Typical Heat Treatments for Wrought Aluminum Alloys

Alloy	Annealing Treatment: Metal Temp, F	Annealing Treatment: Approx Heating Time, hr	Annealing Treatment: Temper Designation	Solution Heat Treatment[a, b]: Metal Temp, F[c]	Solution Heat Treatment[a, b]: Temper Designation[d]	Precipitation Heat Treatment: Metal Temp, F[c]	Precipitation Heat Treatment: Approx Heating Time, hr[e]	Precipitation Heat Treatment: Temper Designation[d]
1100	650	[f]	–0	—	—	—	—	—
2011	775[g]	2-3	–0	950	–T4	320	12-16	–T6
2014[h]	775[g]	2-3	–0	940	–T4[n]	340	8-12	–T6[i]
2017	775[g]	2-3	–0	940	–T4	—	—	—
2018	775[g]	2-3	–0	950	–T4	340	8-12	–T61
2024[h]	775[g]	2-3	–0	920	–T4[n]	375[j]	11-13[o]	–T81
						375[j]	7-9	–T84
								–T86
2025	775[g]	2-3	–0	960	–T4	340	8-12	–T6
2117	775[g]	2-3	–0	940	–T4	—	—	—
2218	775[g]	2-3	–0	950	–T4	460	5-8	–T72
3003	775	[f]	–0	—	—	—	—	—
3004	650	[f]	–0	—	—	—	—	—
4032	775[g]	2-3	–0	950	–T4	340	8-12	–T6
4043	650	[f]	–0	—	—	—	—	—
5005	650	[f]	–0	—	—	—	—	—
5050	650	[f]	–0	—	—	—	—	—
5052	650	[f]	–0	—	—	—	—	—
5056	650	[f]	–0	—	—	—	—	—
5086	650	[f]	–0	—	—	—	—	—
5154	650	[f]	–0	—	—	—	—	—
5357	650	[f]	–0	—	—	—	—	—
6053	775[g]	2-3	–0	970	–T4	350	6-8	–T6
				—	—	450	1-2	–T5
6061	775[g]	2-3	–0	970	–T4	320	16-20	–T6
						350	6-10	
6062	775[g]	2-3	–0	970	–T4	320	16-20	–T6
						350	6-10	
6063	775[g]	—	–0	—	—	450	1-2	–T5
						365	4-6	
						350	6-8	–T6
6066	775[g]	2-3	–0	970	–T4	320	16-20	–T6
						350	6-10	
6151	775[g]	2-3	–0	960	–T4	340	8-12	–T6
7001	775[k]	2-3	–0	870[l]	–W	250[m]	24-28	–T6
7072	650	[f]	–0	—	—	—	—	—
7075[h]	775[k]	2-3	–0	870[l]	–W	250[m]	24-28	–T6
7277	—	—	—	890	–W	[p]	[p]	–T6

[a] Heating time varies with product, type of furnace and size of load.

[b] Should quench from solution heat treating temperature as rapidly as possible and with minimum delay after removal from furnace.

[c] Temperature specified should be attained by all portions of the load as rapidly as possible and maintained for the recommended time with as little variation as possible.

[d] These designations apply to material that has been heat treated by user (see notes [i] and [n] for exceptions). A different designation may apply to material heat treated by producer.

[e] Rate of cooling from precipitation heat treatment temperature is unimportant but should not be unduly slow.

[f] Time in furnace need not be longer than is necessary to bring all parts of load to annealing temperature. Cooling rate unimportant.

[g] This treatment is intended to remove the effect of heat treatment and includes cooling at rate of about 50 F per hour from annealing temperature to 500 F. Rate of subsequent cooling unimportant.

[h] Alclad sheet is heat treated under same conditions as core alloy, but shortest times consistent with securing required properties should be used, and repeated reheats avoided. Prolonged heating or repeated reheats cause diffusion of alloying elements into coating and impair corrosion resistance.

[i] For plate and extrusions, correct temper designation is -T62.

[j] Must cold work after solution heat treatment and before precipitation treatment to secure required properties.

[k] Follow by heating about 6 hr at about 450 F if material is to be stored for extended time.

[l] Sheet may also be heat treated at higher temperatures (up to 925 F) if desired.

[m] Two-stage treatments comprising 4-6 hr at 210 F followed by 8-10 hr at 315 F, or 2-4 hr at 250 F followed by 2½-3½ hr at 325 F are recommended for sheet and cold drawn wire.

[n] For plate and extrusions heat treated by user, correct temper designation is -T42.

[o] For extrusions, time should be 6 hr.

[p] Two-stage treatment comprising 4 hr at 210 F, followed by 8 hr at 315 F.

Source: Aluminum Assn.

◄ For more information, Circle No. 570

RB&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By John S. Davey

Coarse Threads Better Than Fine For Many Jobs

The load and stress concentrations on threads are lower in standard coarse thread fasteners than in fine threaded ones. Flank engagement is also greater because coarse threads are deeper. Except in such cases where fine adjustments are needed, coarse threads are, therefore, preferable to fine threads. They have greater resistance to stripping and, consequently, can be more highly torqued to make a stronger assembly.

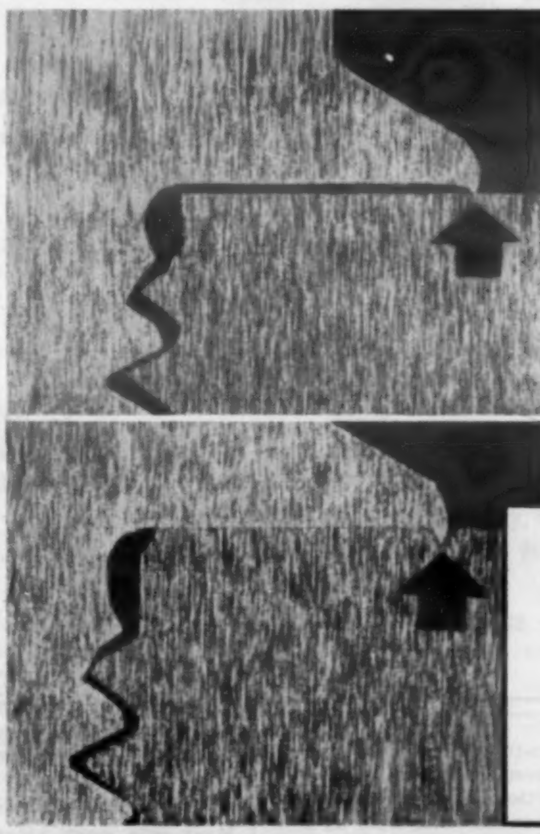
PRODUCTION SAVINGS

Coarse thread fasteners tighten with only two-thirds the revolutions needed for fine threads. So your assembly time is faster, too. Coarse thread bolts enter nuts or mating holes with less tendency to cross thread when not truly positioned. In hard-to-reach areas, this ease of starting can often be your deciding factor. Bear in mind, too, that coarse threads need less "babying" in handling since they're less apt to be damaged.

All in all, coarse threaded standard fasteners prove best for an assembly because of their additional clamping strength—and best for the assembler because of their extra economy and production advantages.

Spin-Lock screws increase holding power by 20%

EXPERIENCE confirms that Spin-Lock screws hold tight under conditions of vibration or repeated heating and cooling. Their strong teeth have a ratchet action on the bearing surface—the acute angle lets the screw tighten fast and easily, until the teeth actually embed into the seat upon tightening, as shown in the sectional photomacrograph below. The almost vertical face of the teeth then resists counter-rotation and loosening. As a result, it takes about 20% more torque to loosen a Spin-Lock than to tighten it.



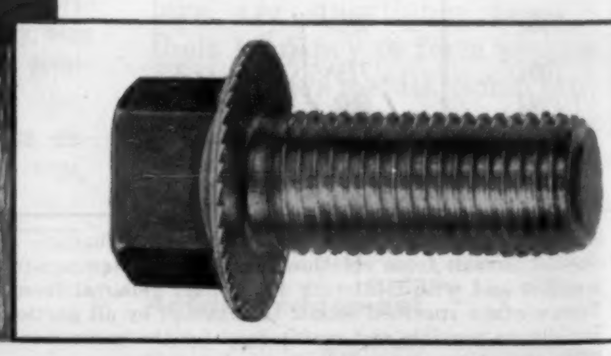
LOWER COST ASSEMBLY

Spin-Lock screws avoid need for washers or external locking devices. One-piece construction, they allow faster assembly and can be easily handled and driven in cramped spaces.

STRONGER ASSEMBLY

Heat treatment gives the teeth hardness and toughness. Spin-Lock screws can, therefore, be reused when removed with but slight loss in holding power. The extra strength also permits tighter fastening for a stronger assembly without risk of stripping threads.

Screws with hex, pan, truss and flat heads are available. See Sweet's Product Designers file or write Russell, Burdsall & Ward Bolt and Nut Company. Plants at: Port Chester, N.Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.



High strength bolts improved product at a saving

A mechanical vibrating shaker naturally suffers severe abuse itself from vibration. One manufacturer of such machines used costly special fasteners and lock nuts to control tendency of the product to loosen up.

Asked about it, RB&W recommended a standard high strength bolt, heavy nut, and two hardened washers. These permitted a high tensile clamping force to be developed. Residual tension was ample for the most severe operating conditions and kept the bolts tight. Result: A 25% saving in annual fastener cost, the constant availability of standard items, and less maintenance for the product. You too can draw on RB&W experience for technical help to assure a strong assembly and to cut costs.

For more information, turn to Reader Service Card, Circle No. 523

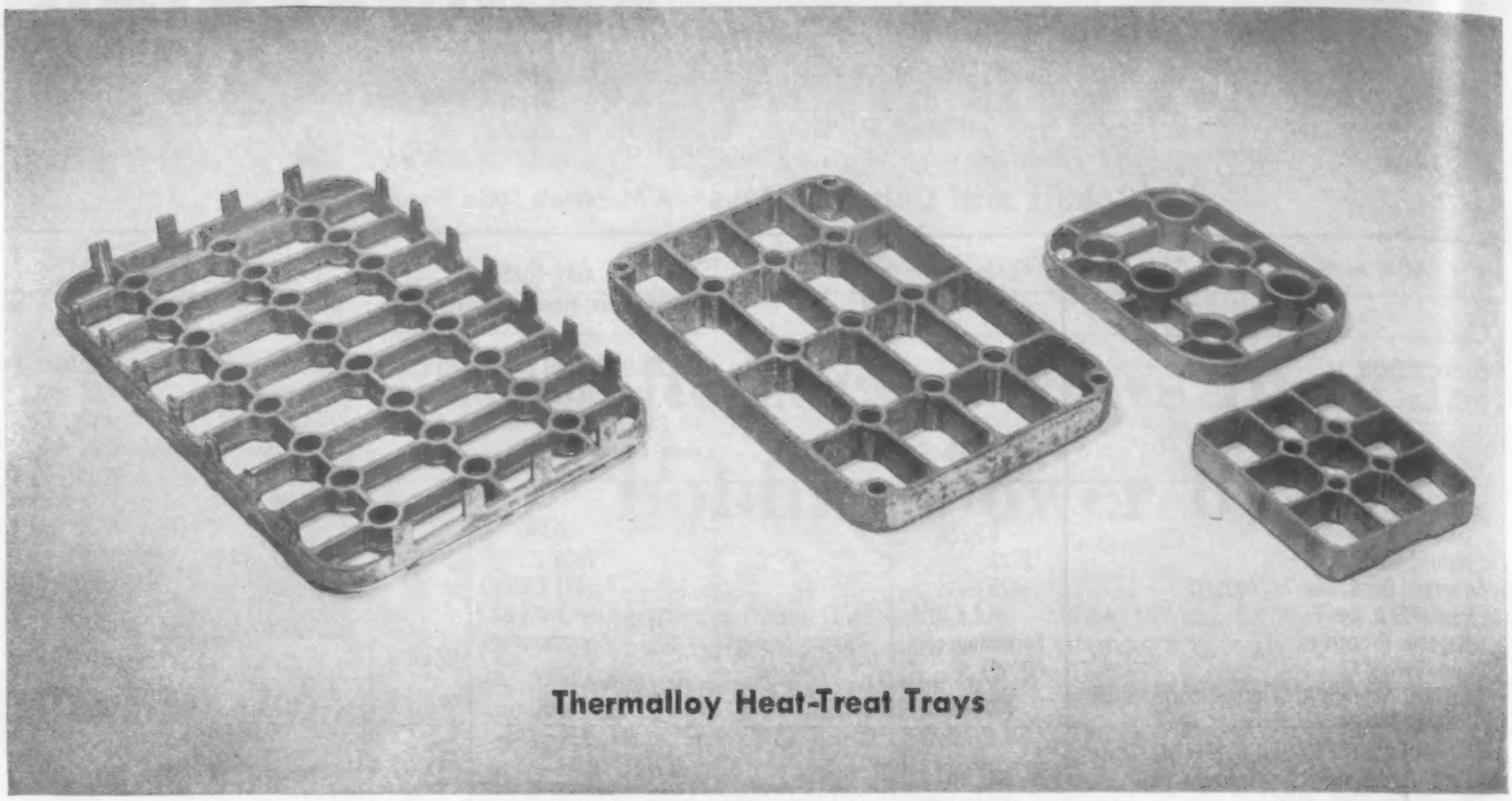
Cobalt and Cobalt Alloys—A Materials Data Sheet

Name	Cobalt		AMS 5385C (Vitallium, Haynes Stellite 21)	AMS 5537 Haynes Alloy No. 25 (L605)
COMPOSITION, %	Co 99.9	C 0.06–0.3 Co 98	C 0.20–0.35, Mn 1.00 max, Ni 1.50–3.50, Mo 4.50–6.50, Cr 25.00–30.00, Fe 2.00 max, Si 1.00 max, B 0.07 max, Co bal	C 0.05–0.15, Mn 1.00–2.00, Ni 9.00–11.00, Cr 19.00–21.00, Fe 3.00 max, W 14.00–16.00, Si 1.00 max, Co 46.00–53.00
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.322	—	0.299	0.333
Melting Point, F	2723	—	2465	2570
Thermal Cond, Btu/hr/sq ft/ft/F	479	—	101 (392 F)	—
Coef of Exp, per F	6.8×10^{-6}	—	7.8×10^{-6}	—
Magnetic Properties	Ferromagnetic	Ferromagnetic	Ferromagnetic	Ferromagnetic
Curie Temp, F	2039	—	—	—
Thermal Neutron Absorption, barns/atom	34.8	—	—	—
MECHANICAL PROPERTIES				
Modulus of Elasticity in Tension, psi	30×10^6	—	16.8×10^6	35×10^6
Tensile Strength, 1000 psi:				
Annealed	37	43–75	—	145-165
Sintered	98.5	—	—	—
Cold Worked	100	—	—	—
As Cast	34.4	61.0	103	—
Aged 50 hr at 1300 F	—	—	125	—
Yield Strength, 1000 psi:				
Annealed	28–41	20–65	—	65–85
Sintered	43.8	—	—	—
As Cast	20–43	33	82	—
Aged 50 Hr at 1300 F	—	—	110	—
Elongation in 2 in., %:				
Annealed	0–8	13	—	70–55
Sintered (1 in.)	13.5	—	—	—
Cold Worked	2–8	—	—	—
As Cast	0–4	5–30	8	—
Aged 50 Hr at 1300 F	—	—	2	—
Hardness, Bhn:				
Annealed	121–131	138	—	225
Sintered (VHN)	173	—	—	—
As Cast	124–130	100–131	R_a 65	—
Aged 50 Hr at 1300 F	—	—	R_a 71	—
Electrolytic	270–310	—	—	—
Compressive Strength, 1000 psi:				
Annealed	117.2	140.0	—	—
As Cast	122.0	175.0	—	—
Modulus of Elasticity in Shear, psi	11.1×10^6	—	—	—
Impact Strength (Charpy V-notch), ft-lb:				
Room Temp	—	—	2.9	120[a]
1500 F	—	—	11.0	—
THERMAL TREATMENT				
Annealing Temp, F	—	—	2175–2200	2225
Solution Temp, F	—	—	—	2200
Hardening Temp, F	—	—	1475–1500	—
Aging Time, Hr	—	—	5-50	—
FABRICATING PROPERTIES				
Hot Working Temp Range, F	930–1100		—	—
Machinability	Possible	Possible	Poor	Good
Weldability	—	—	Shielded arc	Good
CORROSION RESISTANCE	Excellent	Excellent	Resistant to oxidizing media, flue gases, etc.	Highly resistant to scaling and oxidation at elevated temperatures
AVAILABLE FORMS	Rondelles, powders	Rondelles, powders	Precision castings, sand castings, bar, sheet, welding rod	Sheet, plate, bar, tubing, wire

[a] Izod impact strength on notched or unnotched specimen; actually the specimen stops pendulum.

Prepared by F. R. Morral, Battele Memorial Institute

WHAT'S YOUR HEAT-TREAT PROBLEM?



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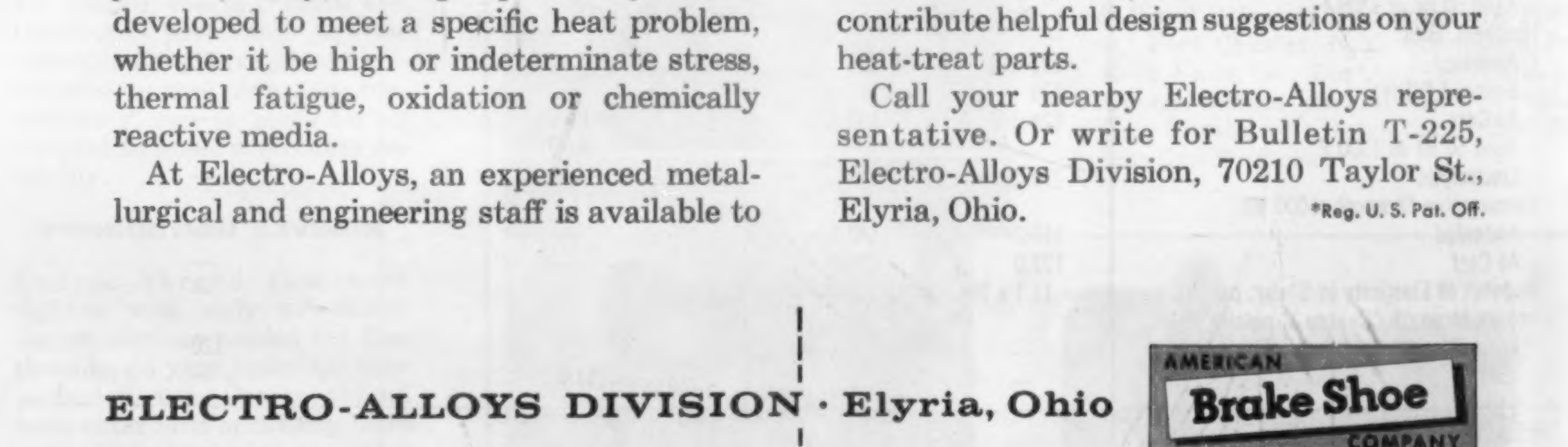
AMERICAN Brake Shoe COMPANY



For more information, turn to Reader Service Card, Circle No. 391

NEW MATERIALS PREVIEWS

This month

- *Boride coating for metals*
- *Medium-density polyethylene*
- *Vacuum melted nickel alloy*

Attacked, uncoated iron *sample at bottom was immersed in liquid aluminum for 24 hr at 1450 F. Boride-coated sample at top is completely unharmed after exposure for more than 800 hr.*

Boride Coating Protects Metals Exposed to Molten Aluminum

■ A newly developed boride coating designed to protect iron and steel parts against corrosive attack by liquid aluminum is expected to facilitate the continuous processing of aluminum and the production of aluminum die castings. Details of the coating have been announced by the Nuclear Engineering Div., *Penn-Texas Corp.*, 730 Fifth Ave., New York 22.

The coating—now being used in a number of applications—consists of a boride base material which has excellent oxidation resistance to above 1800 F. Tests indicate that a life of 1200 hr at 1500-1550 F is readily obtainable.

Best on mild steel

Protection against liquid aluminum is available for a wide range of steel and cast iron parts. Mild steel is preferred to stainless steel because of the better bond that can be obtained. If desired, however, the boride material can be deposited on various grades of stainless steel. In some special cases an undercoating may be required. Porosity of the coating has no effect on its behavior in liquid aluminum because of a complete lack of wetting between the liquid metal and the coating material. To prevent attack of the coating, fluoride fluxes should not be used.

The coating material is available in the form of rods about 1 in. long and 1/8 in. in dia. The rods are quite strong and can be fed directly into a flame-spray gun. Practically any gun can be used; however, some modifications may be required to assure a slow and well controlled feed through the extremely hot flame required to melt the boride material. If the feed is too fast, the material does not have enough time to reach full temperature and may not adhere properly. If handling is done properly, the base material does not reach a temperature above 400 F.

Present applications

A special application of the coating is the protection of thermocouple tubes that are immersed in liquid aluminum. Previously, these tubes were immersed only for short periods or were made from low conductivity ceramic materials which cracked easily. Steel tubes protected by the new boride coating can be kept in the molten metal for long periods with little danger of attack.

Boride-coated transfer troughs, which withstand attack by streams of molten aluminum for long time periods, have facilitated continuous metal processing. Coated wheels and pulleys for guiding steel wires through liquid aluminum are also capable of extended use. Atomizing nozzles and die casting pumps are other suggested applications.

***Higher rigidity** of medium density material is shown in cup at top. Taken from the same mold, cup at bottom is of standard polyethylene.*

Medium-Density Polyethylene Available in U. S.

Commercial quantities of polyethylene resins with densities intermediate between those of conventional high pressure polyethylenes and the newer low pressure polyethylenes are now available from *Spencer Chemical Co.*, 610 Dwight Bldg., Kansas City 5, Mo.

With specific gravities ranging from 0.935 to 0.940, the new resins, trademarked Poly-Eth Hi-D, are quite similar in properties to Imperial Chemical Industries' Alkathene HD, announced in M&M May '55, p 165. The higher density of the new resins provides improved rigidity and tensile properties, as well as higher temperature resistance and dimensional stability, compared with conventional polyethylenes. The resins are produced by a Spencer-developed modification of the conventional high pressure polymerization method. Estimated price in commercial quantities is 47¢ per pound.

Poly-Eth Hi-D resins have a Vicat softening temperature of 235 F, permitting the use of polyethylene in containers and other products which must be subjected to temperatures higher than conventional polyethylene can withstand. The improved rigidity and tensile properties permit economical reductions in wall thickness of some types of parts without corresponding losses in strength. Also, according to Spencer, the as-molded material has higher gloss and better abrasion resistance than conventional polyethylenes. Faster mold cycles are said to be possible, since the part can be removed from the mold at higher temperatures.

The accompanying table compares properties of the new resins with those of a typical conventional polyethylene. The 0.935-0.940 specific gravity indicates a degree of molecular linearity between that of the 0.920-density conventional or branched chain resins and the 0.960-density (maximum density) low pressure or linear resins. This intermediate degree of crystallinity results in values for properties such as rigidity, tensile strength and heat resistance that are intermediate between those of conventional and low pressure polyethylenes.

HOW "POLY-ETH HI-D" COMPARES WITH A CONVENTIONAL POLYETHYLENE

Property	ASTM Test Method	"Poly-Eth Hi-D"	Conventional Polyethylene
Specific Gravity	D 792-50	0.935*	0.918
Nominal Melt Index, gm/10 min	D 1238-52T	1	1
Ultimate Tensile Strength, psi	D 412-51T	2400	1850
Yield Strength, psi	D 412-51T	2400	1200
Elongation, %	D 412-51T	425	575
Stiffness Modulus (73 F), psi	D 747-50	35,000	13,000
Hardness, Shore Durometer	D 676-49T	D 56	D 44
Vicat Softening Point, F	—	235	200
Brittleness Temperature, F	D 746-52T	< -100	< -100
Impact Strength (Izod, 73 F), ft-lb/in. notch	D 256-54T	Did not break	Did not break
Power Factor	D 150-47T	<0.0003	<0.0003
Dielectric Constant	D 150-47T	2.3	2.3

* Range is 0.935 to 0.940.

Wherever you look

there's *Stainless*

And there will be even more stainless steel used on the cars of tomorrow. Designers know that automobile buyers are becoming increasingly conscious of the fact that stainless steel fights rust, pitting and road abrasion with much greater success than any other metal. Parts made of stainless steel stay newer longer — require far less elbow grease to maintain.

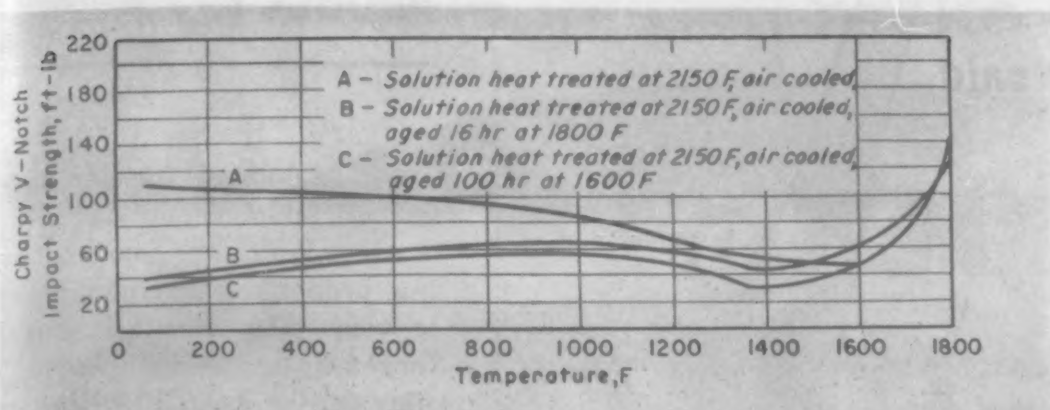
Unusual brightness of finish, plus the consistent uniformity of every inch of every coil, are two big reasons why Sharon has always been a major supplier of stainless steel to the automotive industry.

This Sharon quality and familiarity with the industry's needs can be invaluable production assets to you.

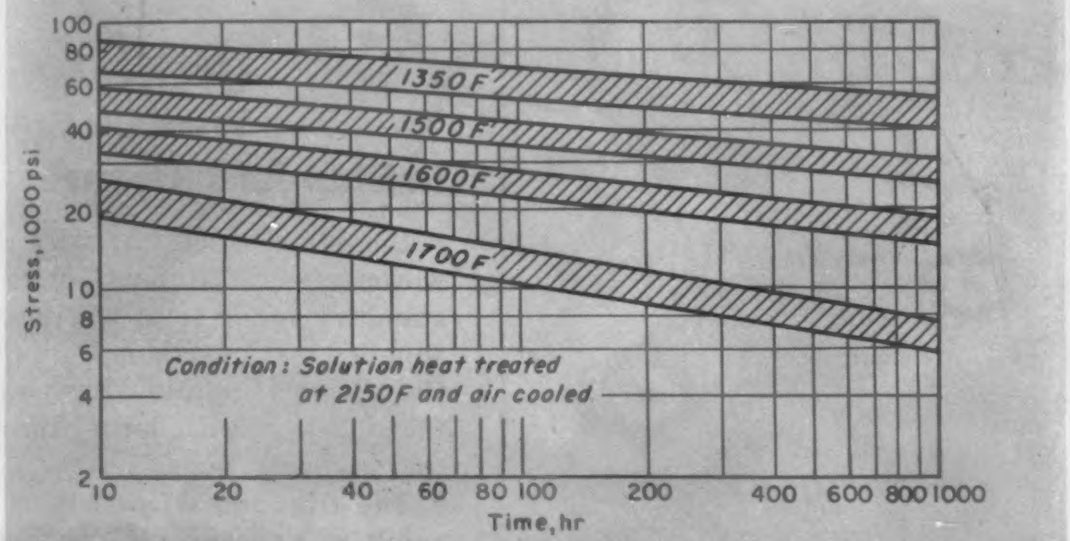
SHARON *Stainless Steel*

SHARON STEEL CORPORATION *Sharon, Pennsylvania*

DISTRICT SALES OFFICES: Chicago, Cincinnati, Cleveland, Dayton, Detroit, Grand Rapids, Indianapolis, Los Angeles, Milwaukee, New York, Philadelphia, Rochester, San Francisco, Sharon, Seattle, Montreal, Que., Toronto, Ont.



Impact strength *of Hastelloy R-235.*



Stress rupture *properties of Hastelloy R-235.*

Vacuum melting produces clean material

High Strength Nickel-Base Alloy for High Temperature Service

■ A new precipitation hardening nickel-base alloy with excellent properties at temperatures through 1750 F has been announced by *Haynes Stellite Co.*, Kokomo, Ind. The alloy has good oxidation resistance, a low content of strategic alloys and high resistance to overaging in service. It is available as sheet, plate, bar stock, wire and forging billets.

Hastelloy Alloy R-235 has a nominal composition of 66 nickel, 15 chromium, 10 iron, 5 molybdenum, 2 aluminum, 2 titanium, 2.5 cobalt (max) and 0.16% carbon (max). Production by vacuum melting makes it possible to obtain a material of closely controlled composition which is clean and free from "tramp" elements.

Although the alloy is precipitation hardenable, no complicated heat treatments are required to develop its properties. A solution heat treatment at 2150 F followed by air cooling is sufficient, except for light sections where a short age hardening treatment at 1600 F for 10 min to 1 hr is sometimes desirable.

R-235 has a room temperature tensile strength of about 167,000 psi and a yield strength of 100,000 psi. Strength and ductility remain relatively high up to 1800 F. The alloy also has unusually good impact strength. Solution heat treated bar has an average Charpy V-notch impact strength of 107 ft-lb at room temperature.

Although precipitation in the alloy is rapid at elevated temperatures, the particles remain small and agglomerate slowly. There is little decrease in strength during long exposure at elevated temperatures. As a result, stress rupture strength of the new alloy is outstanding up to 1750 F. Stress for rupture in 100 hr at 1500 F is

SHORT TIME TENSILE PROPERTIES

Form	Condition: Solution Heat Treatment Temp, F	Condition: Aging Temp, F	Condition: Aging Time, Min	Test Temp, F	Ten Str, psi	Elong, %
Sheet, 0.109 in.	2150, air cool	—	—	Room	147,000	43
				1500	90,000	5
				1650	55,000	9
				1800	21,800	38
				1950	9600	74
Sheet, 0.050 in.	2150, air cool	1600	25	1350	122,000	4.5
				1500	88,000	6.5
				1650	53,700	8
				1800	22,000	16
				1900	11,300	56
Bar	2150, air cool	—	—	Room	167,000	32
				1500	97,000	10

PHYSICAL PROPERTIES

Density, lb/cu in.	0.296
Melting Point, F	2400
Therm Cond, Btu/hr/sq ft/ft/F:	
212 F	6.0
1700 F	15.0
Coef of Exp per F (70–1800 F)	9.7x1C^{-6}
Spec Ht, Btu/lb/F (calc.)	0.1096
Elect Res, microhm-cm at 72 F	53

◄ For more information, Circle No. 477

about 38,000 psi for bar and 37,000 psi for sheet.

Alloy R-235 has good hot working properties and can be rolled to very thin sheet. It has been forged into turbine blades. The alloy can be welded by spot, seam, sigma and Heliarc welding methods.

Titanium Wire Cloth in Standard Meshes

Industrial grades of wire cloth woven from titanium wire in standard mesh sizes can now be supplied by *Cambridge Wire Cloth Co.*, Cambridge, Md. Sizes range from 60 mesh down through coarse sizes.

The titanium wire cloth is the result of experimental work done by Cambridge with du Pont and Rem-Cru Titanium Co. In one application titanium cloth has been used to filter highly corrosive materials for more than seven months with no evidence of attack. Stainless steel cloth used in the same application showed severe pitting after only one or two weeks' service. Other potential uses for titanium wire cloth include medical prosthetics, screening of hypochlorite and chlorine dioxide in the pulp and paper industry, and jet engine screens for aircraft.

Magnesium-Thorium Sheet Is Available

Magnesium - thorium (HK31A) sheet is now available from *Dow Chemical Co.*, Midland, Mich., in adequate stocks for delivery for high temperature aircraft development projects. The material is the first of a new series of magnesium elevated temperature alloys containing thorium, zirconium and manganese in various combinations.

HK31A retains good short-time properties up to 800 F and good

now truly HEAT SEALABLE foam . . . VINYL foam

and suddenly 1000 great ideas are possible!

Development of *heat-sealable* Vinyl-foam, makes new quality, new ideas possible in hundreds of products that require cushioning or softness, fashionably molded contours, eccentric or specially-designed shapes, quick-quilted and embossed surfaces.

In all these ideas, quality is maintained. Electronic heat-sealing affects none of Vinylfoam's many desirable properties.

Exon 654, vinyl plastisol resin helps make Vinylfoam unusually resistant to abrasion, corrosion, flame, aging, moisture, tearing and chemical action. Prevents shrinking, oxidizing, hardening or drying out, all with maximum dimensional stability.

Vinylfoam, produced by the Elastomer Process, can be molded in either cored or uncored form, with or without surface contours. It can be embossed, die cut, split or skived. You can bond Vinylfoam directly onto textiles, most synthetics, and on vinyl sheeting or film in continuous lengths.

Vinylfoam is so versatile that products in almost every industry can acquire new comfort, safety and durability. And with vinyl's economy, they will cost less, sell better.

because it's made of

Firestone

EXON

VERSATILE VINYL RESINS

engineered answers to industry's needs

Firestone Plastics Company supplies only the plastisol resin . . . does not make the finished foam.

For complete information or technical service on EXON resins, industry's most complete line of versatile vinyls, call or write:

CHEMICAL SALES DIVISION

FIRESTONE PLASTICS CO., DEPT. 63N, POTTSTOWN, PA. • A DIVISION OF THE FIRESTONE TIRE & RUBBER CO.

For more information, turn to Reader Service Card, Circle No. 465

long-time properties up to 600 F. The alloy has good corrosion resistance and is lightweight. Consequently, it can be used in relatively thick sheets that resist buckling better than thinner sheets of heavier metals. The sheet is rolled in gages from 0.016 to 2 in. and is furnished in hard rolled (—H24) and annealed (—0) conditions. It can be sheared, drawn, spun, arc welded, spot welded and riveted. Severely formed parts can be drawn at temperatures in the range of 600 to 700 F.

Because of the alloy's thorium content, users must be individually licensed by the Atomic Energy Commission.

Clear Thermosetting Sheet is Antistatic

A thermosetting plastic developed by *Homalite Corp.*, 11-13 Brookside Drive, Wilmington 4, Del., can be used in many places where plastics formerly were not satisfactory. Called Homalite 141, the plastic has inherent antistatic qualities that prevent the accumulation of static electricity on its surface. The material is claimed to be ideal for sensitive instru-

***Thermosetting plastic** has permanent antistatic properties.*

ments where static affects accuracy. It does not attract or pick up dust and its properties are retained indefinitely.

Homalite 141, which resists crazing, is a strong, clear sheet with excellent heat resistance. Its light weight and high scratch resistance are said to make it a good transparent material where heat, fracture and chemical resistance problems are common.

Protective, Antistatic and Friction Coatings

Recent developments in coatings include a finish for vinyl plastisols, a universal finish for plastics and an antistatic coating that utilizes a Teflon base. These and seven other new developments are described below.

1. Vinyl plastisol finish

A finish for vinyl plastisols is reported to have good adhesion to a wide variety of plastisol formulas. Designated N 230, it is marketed by *Logo, Inc.*, 12933 S. Stony Island Ave., Chicago 33. The finish is said to provide good flexibility and extensibility along with good aging qualities. It is claimed not to be adversely affected by migration of plasticizers from plastisol formulations. Nonlead bearing pigments are available for toy and related applications.

2. Strippable coating

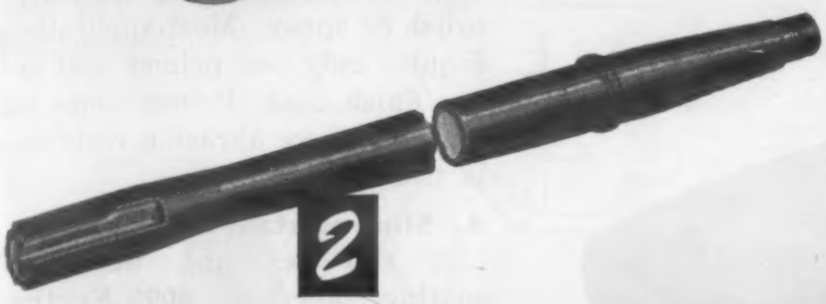
A strippable coating that prevents mars and scratches during processing, shipment and storage has been developed by *Chemical Consulting Service*, 3711 S. Clement Ave., Milwaukee 7, Wis. Called Strip-Kote, it is used for protecting smooth and wrinkle metal finishes, enamel and lacquer finishes, highly machined precision parts, plastics, glass and chromium plated surfaces.

The coating, a milky colored, latex type of emulsion, contains no organic solvents. The film becomes transparent, tough and permanently flexible after the coating

(continued on p 154)

7 WAYS to SAVE MONEY with TOCCO* Induction Hardening

Cost was reduced 94% when heat-treatment of this corn-harvester part was changed from carburizing to TOCCO-hardening, 9½c saved on every piece — $4750 on each 50,000 piece batch, plus an hourly production increase from 120 to 300 pieces per hour.

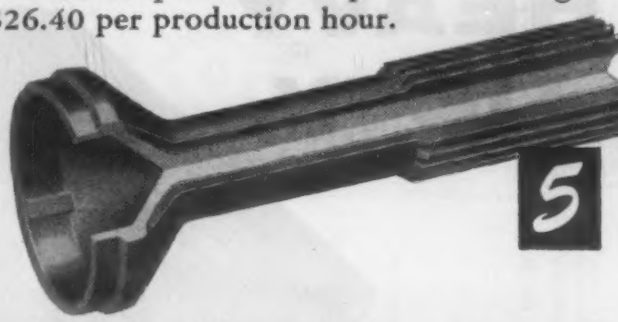


Leading automotive companies need and use TOCCO hardened axle shafts to handle higher horsepower. Better, yet cheaper—savings of $375.00 per day. Less machining costs, lower priced material, increased production, and a plus in quality—200% greater torsional life.

Kearney & Trecker Corp. reduced the cost of hardening this milling machine part from $1.57 to 10c apiece. In addition TOCCO made possible a switch from alloy to S.A.E. 1045 steel—saving another 11c per piece in material cost. Kearney & Trecker hardens 140 different parts on one TOCCO unit.

See Us At Booth 2212
Nat'l Metals Exposition—Cleveland—Oct. 8-12

Thompson Products Ltd. boosted production of these automotive wrist pins from 500 to 1200 per hour when they switched to TOCCO-hardening. Costs fell from $5.45 to $3.25 per hundred parts—a savings of 2c per pin, $26.40 per production hour.

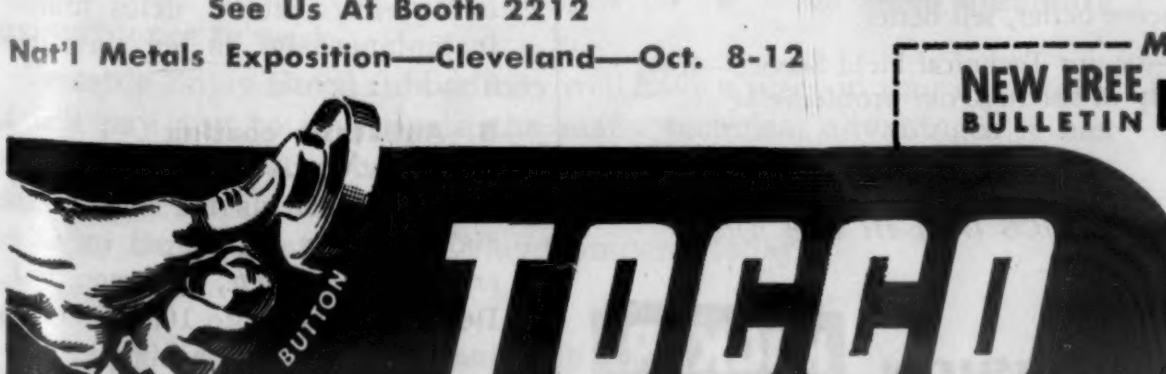


Mechanics Universal Joint Division of Borg-Warner reports a 69% savings in the hardening of stub ends for propeller shafts. TOCCO also upped production from 35 to 112 parts per hour—over three times as fast as conventional heating methods.

Lima-Hamilton Corporation adopted TOCCO for hardening this shifting lever. Results: a savings of 4c per piece—$25 per production hour. TOCCO costs only 17% of former heating method. This is only 1 of 139 parts TOCCO-hardened by Lima-Hamilton Corp. All show savings over usual heating methods.

7

Number 7—the lucky number—is up to you. Why not add your name to the list of companies who use TOCCO Induction Heating to increase production, improve products and lower costs. TOCCO engineers are ready to survey your plant for similar cost-saving results—without obligation, of course.



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Dept. T-10, Cleveland 1, Ohio

Please send copy of "Typical Results of TOCCO Induction Hardening and Heat Treating."

Name__________
Position__________
Company__________
Address__________
City______ Zone____ State______

• For more information, turn to Reader Service Card, Circle No. 403

air-dries for 20 to 30 min. It is easily stripped. Coverage is 250 sq ft per gal for an 0.008-in. film.

3. Primer and enamel

A new enamel and a rust resistant top coat primer have been developed by *Robeson Preservo Co.*, Port Huron, Mich. Both are designed for use on heavy equipment such as earth movers, tractors, trucks, and in-plant machines. The enamel, which comes in 14 high gloss colors, is claimed to possess high coverage and good color retention. It is applied by brush or spray. Most applications require only one primer coat and one finish coat. Primer alone can be used where abrasion resistance is not required.

4. Slip resistant coatings

A slip resistant, waterproof coating, called No. 3095 Friction-Kote, is supplied in emulsion form by *Dennis Chemical Co.*, 2701 Papin St., St. Louis 3, Mo. It is applied to kraft paper or board after printing and before fabrication into single or multiwall bags, paperboard boxes and corrugated boxes. In addition to providing friction to avoid slipping in transit and handling, the coating prevents the inks from rubbing off and waterproofs the container.

Another antiskid coating for corrugated shipping cases has been developed by *National Adhesives, Div. of National Starch Products, Inc.*, 270 Madison Ave., New York 16. Designated Resyn 32-4150, it is applied by spray to the bottoms of cases as they leave the case seal. The coating, which is water resistant, dries almost instantaneously as an invisible film.

5. Antistatic coating

A new antistatic coating that utilizes Teflon as the base material has been announced by *General Plastics Corp.*, Paterson, N.J. Designated Gencote 108, the coating provides an antistick, dry lubricated, chemically inert surface that is antistatic as well. Applied on the interior of

For more information, turn to Reader Service Card, Circle No. 499

OTHER NEW MATERIALS PRODUCTS

chemical and dry cone blenders, the coating is said to prevent light powders from sticking to the sides. The antistatic feature also permits powders to flow freely on conveying equipment. Used on the guide surfaces in high speed cameras, Gencote 108 reduces friction between the platens and the film, eliminating static sparking. The coating also eliminates accidental detonation by static discharge in the mechanical handling of explosive materials.

When applied in a 4-mil film, the coating has an electrical resistance of about 1 ohm. Surfaces can be coated in multiples of ½ mil up to 10 mils on any type of metal or other material that can withstand the 700 F temperature required for the baking process. The coating can also be used to provide an electrically conductive surface on an insulating base such as glass, a ceramic or porcelain.

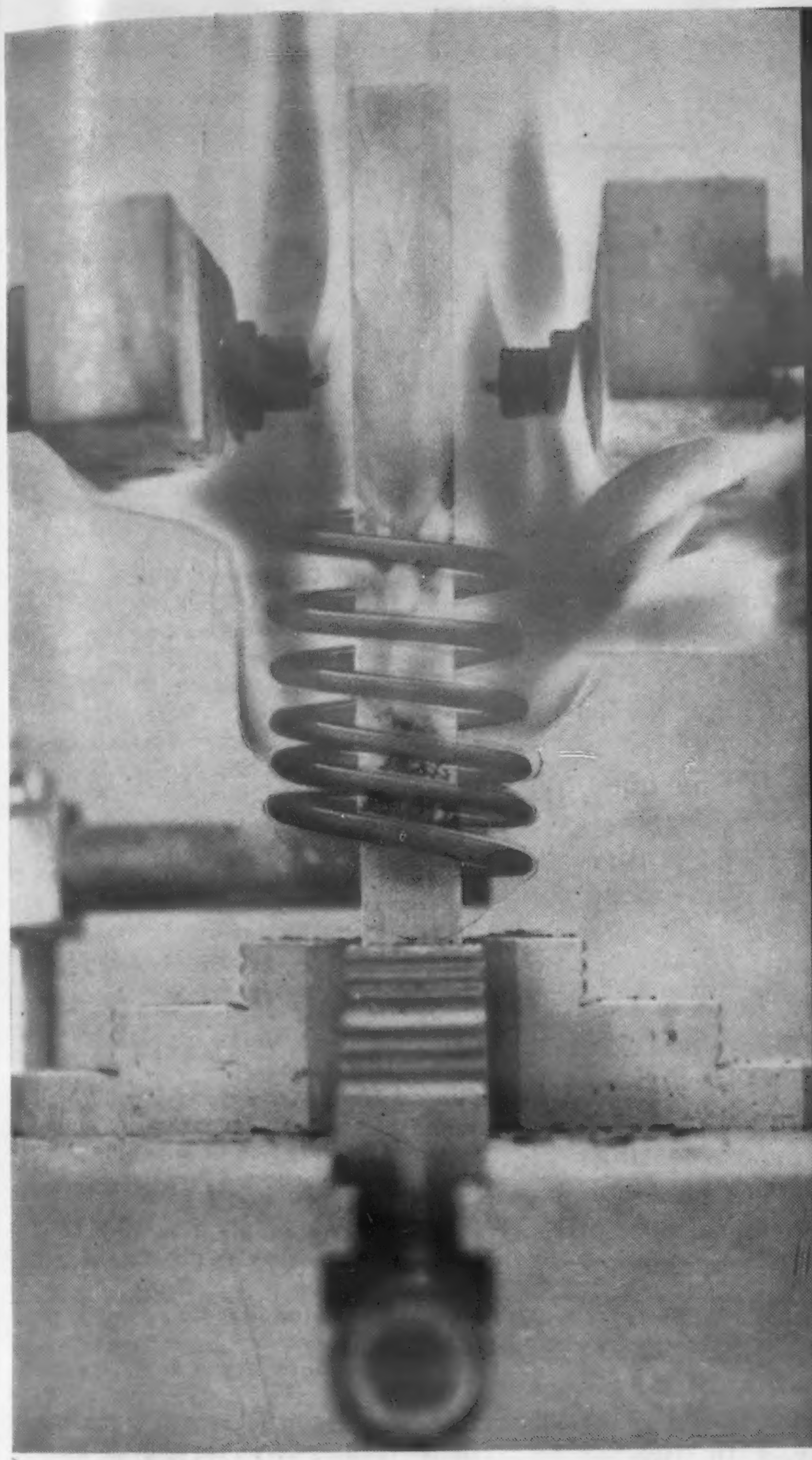
6. Corrosive protection

A plastics finish has been developed especially for metal and wood surfaces subject to unusually corrosive conditions. Called Guardon, it is marketed by *Surface Coating Engineers, Inc.*, 2417 N. Burdick St., Kalamazoo, Mich. Applied by brushing, spraying or dipping, the two-component finish incorporates a modified catalytic epoxy with other synthetic resins. It air-dries in 6 hr and bakes glossy hard in 8 min at 350 F.

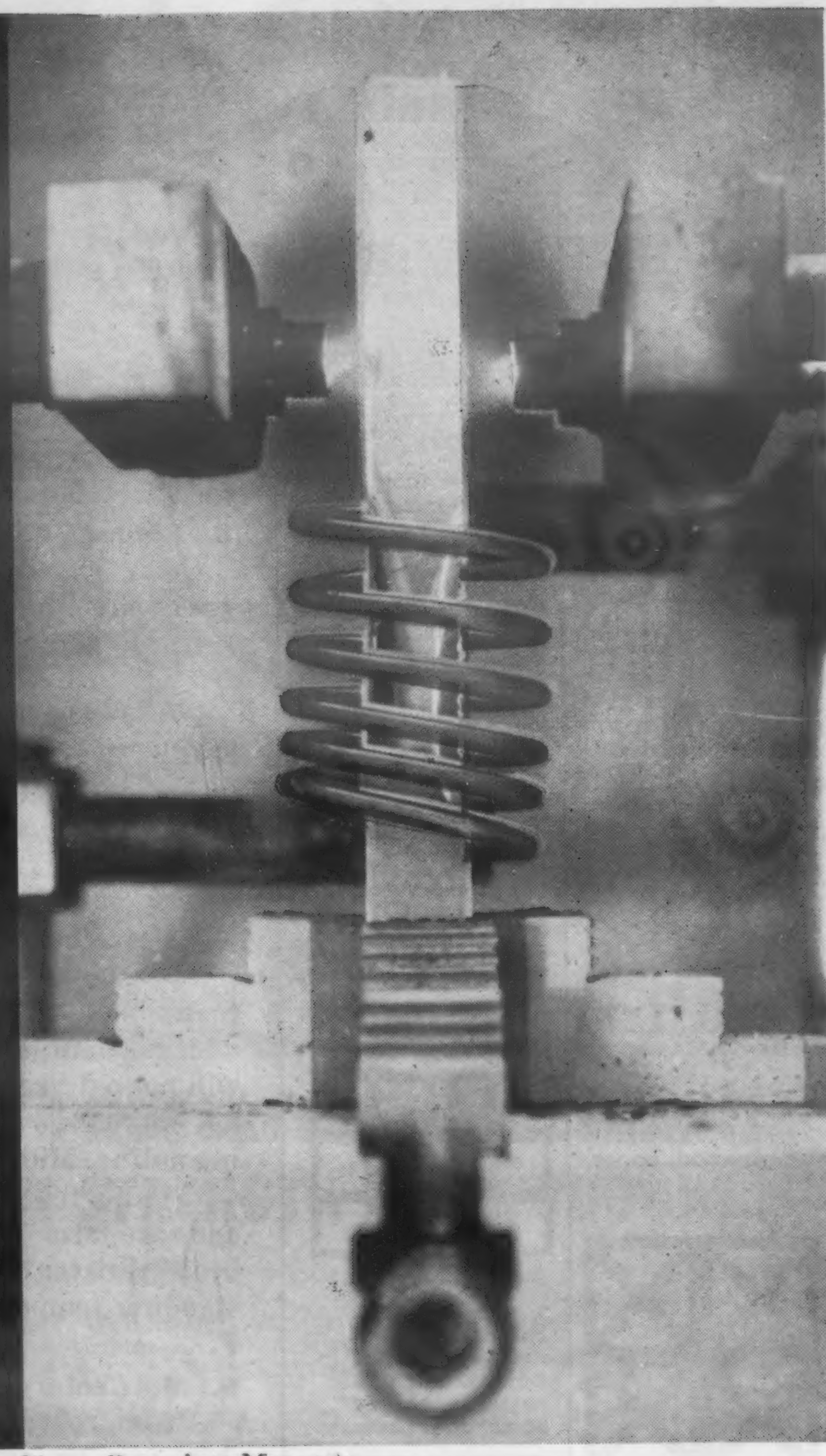
Guardon is claimed to form a tough, flexible coating that resists acids, solvents and temperatures up to 800 F. Metals require one coat, wood two. It is available in any color as well as clear and in hammertone, metallic and leather-like finishes. Pot life is claimed to be at least 3 days at 72 F.

7. Universal finish for plastics

A universal spray finish that is suitable for decorating most plastics is available from *Logo, Inc.*, 12933 S. Stony Island Ave., Chicago 33. Called Logo R-200, it is reported to work well on all polystyrenes, copolymers and other



Normal insulation



Flame-Retardant MICARTA

Five times more insulation protection with NEW flame retardant micarta

New Westinghouse flame-retardant MICARTA gives you 500% more protection than existing xxx insulation material.

When exposed to arcing caused by high-ampere currents, Westinghouse flame-retardant MICARTA is slower to ignite . . . extinguishes its own flame when arcing ceases. Fire extinguishing ingredients in the insulation release a gas that quickly retards the flames, preventing fire from spreading to other components. Fibrous insulation just can't measure up to MICARTA'S fire-resistant characteristics. Why gamble with inferior products? Specify Westinghouse flame-retardant MICARTA, the high-quality insulation.

Available in thickness of 1/8" through 3/4" in standard-size sheets, or rectangular tubing. Physical properties for flame-retardant MICARTA meet or exceed NEMA specifications.

J-06629

More information?

MAIL THIS COUPON . . . TODAY

Westinghouse Electric Corporation,
Micarta Division, Trafford, Pa.

Please send me more information on flame-retardant Micarta.

Name ____________

Address ____________

City ____________

State ____________

WATCH WESTINGHOUSE WHERE BIG THINGS ARE HAPPENING FOR YOU!

For more information, turn to Reader Service Card, Circle No. 501

OTHER NEW MATERIALS PRODUCTS

plastics including most flows of butyrates. It is used as an air dry finish for thermosetting plastics such as phenolics and polyesters. The new coating eliminates the need for a separate finish for each specific plastic.

8. Colored aluminum coatings

Gold, silver, cobalt blue and green aluminum coatings are marketed by *Duncan-Stewart Industries, Ltd.*, 715 Fifth Ave., New York 17. The coatings, called Multi-Purpose, are available in 16 oz spray cans and in larger quantities for brush, roller or power spray. They provide decorative, waterproof protection for metal, wood or other type surfaces.

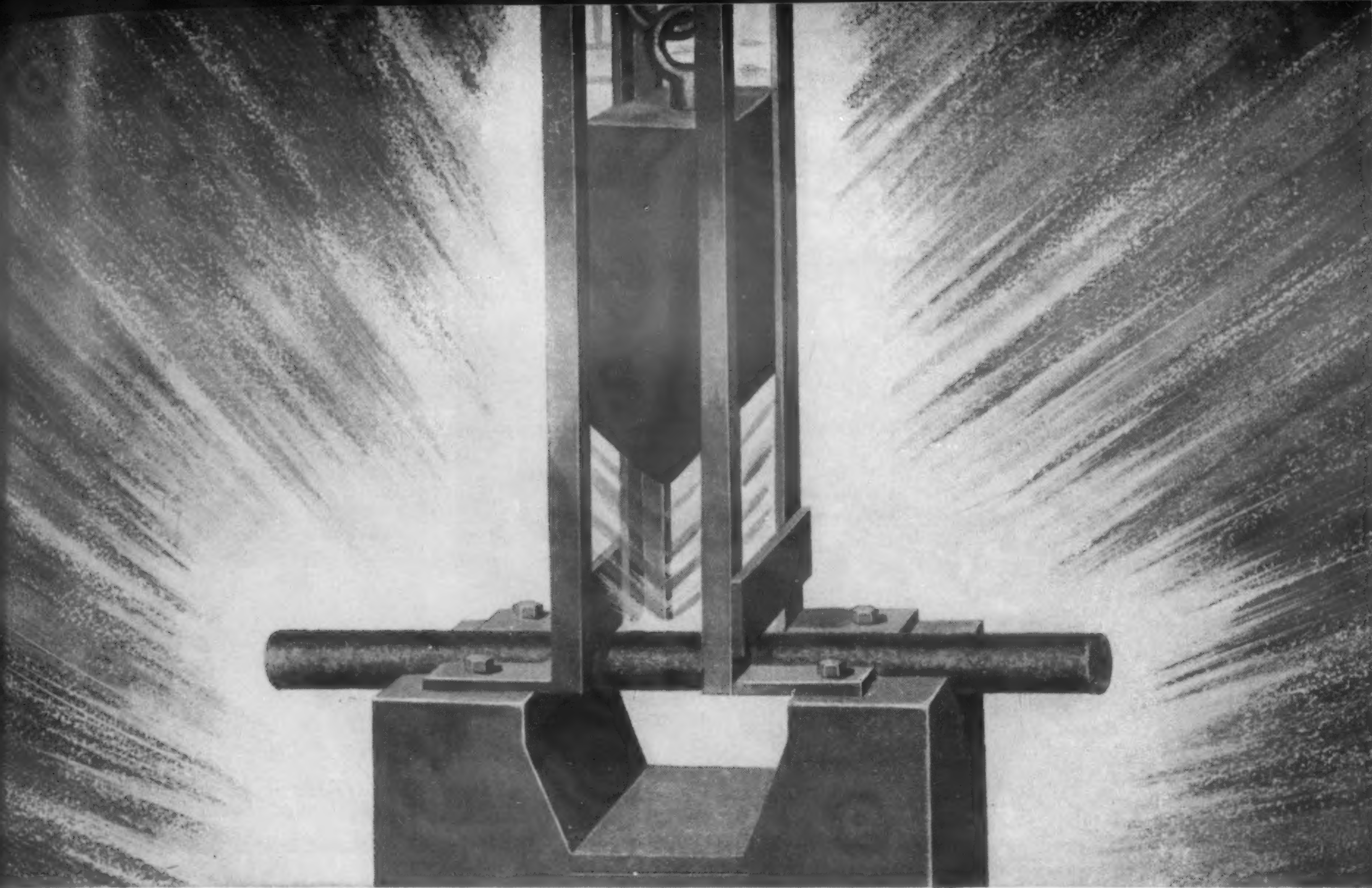
The coatings, which are nontoxic, have a synthetic resin base and an aluminum pigment. They will not oxidize or corrode and are not discolored by fumes containing sulfur. Multi-Purpose coatings withstand temperatures to 250 F and are also made in a special heat resistant type capable of standing temperatures up to 1000 F.

9. Multicolored paint

An improved multicolored paint that can be sprayed in two or more colors at one time from a single container has been developed by *Duralac Chemical Corp.*, 84 Lister Ave., Newark 5, N. J. Called Poly-Nam, it can be readily applied to wood, paper and metal. The paint air-dries to touch in 1 hr and dries to a semigloss finish in 4 hr.

Rayon-Vinyl Covering Is Strong and Light

A translucent fabric for tarpaulins and similar protective coverings has been developed by *Herculite Protective Fabrics, Inc.*, 140 Little St., Belleville, N. J. The material combines high strength, low weight and weather resistance. It is made of loose mesh weave Fortisan-36 (a Celanese



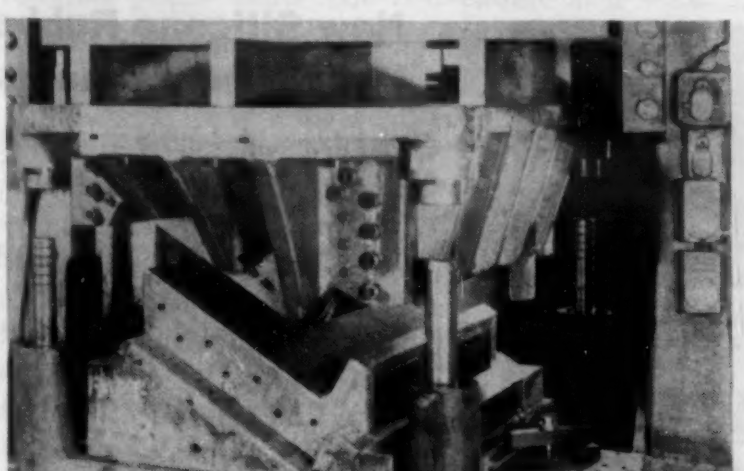
EXCELLENT SHOCK-RESISTING PROPERTIES OF MEEHANITE CASTINGS OFFER PROOF OF HIGH STRENGTH AND TOUGHNESS

PERMANENT DISTORTION

Impact Foot Pounds	Mild Steel: Deflection	Cast Steel: Deflection	Type GA Meehanite, As Cast: Deflection	Type GAH Meehanite, Heat-Treated: Deflection
10	0	0	.001	0
12½	.005	.005	.004	0
15	.007	.007	.008	0
17½	.024	.027	.013	0
20	.037	.047	.019	.002
22½	.048	.064	.027	.005
25	.071	.089	.033	.006
27½	.098	.110	.042	.007

These drop test results provide a measure of the impact strength of Meehanite. Test bars (1" dia. x 8" long) were subjected to a series of blows from different heights.

Structurally controlled Meehanite Metal Castings are available in 26 different property combinations to meet exacting engineering requirements. When superior shock-resistant qualities combined with strength and wear resistance are demanded, Meehanite Metal control provides designers and engineers with assurance of casting uniformity and dependable job performance. *For more information, send for your copy of the "Principles of Heat Treatment."*



Meehanite Forming Dies give longer service life and freedom from scuffing and galling.

Meehanite Metal Tooth Caps for heavy-duty land clearing rakes provide long wear life without failure under severe impact conditions.

MEEHANITE METAL®

MEEHANITE METAL CORPORATION • NEW ROCHELLE • NEW YORK


Translucent *rayon-vinyl laminate is strong, dimensionally stable.*

high strength rayon) laminated between two outer vinyl films (Bakelite's Krene). Fortisan-36 is resistant to sunlight degradation.

Among initial uses foreseen for the vinyl-laminated Fortisan-36 fabrics are linesmen's tents, hatch covers, and portable repair shelters. Consumer applications may include translucent awnings that will provide soft shade for intense sunlight without blotting out all light. For these uses the vinyl can be supplied in various colors.

New Silicone Rubbers Use Standard Molds

Three advanced silicone rubber compounds have been announced by *Goshen Rubber Co., Inc.*, Goshen, Ind. The compounds are particularly suitable for making O-rings complying fully with AN, MS, SAE, JIC and NAS dimensions and tolerances, but can also be used to make other silicone rubber parts. They are supplied in durometer hardnesses of 60, 70 and 80, and are useful over a −80 to 500 F range.

The compounds are said to be unique in that mold shrinkage

For more information, turn to Reader Service Card, Circle No. 502

duplicates that of organic rubbers. This factor eliminates previously required special tooling, tool construction time delays and high rejection rates. Other advantages include maintenance of consistent, in-tolerance dimensions and use of greater capacity standard tooling with resulting lower unit costs. The three compounds are nontoxic, which makes them suitable for food and beverage processing applications. They have zero moisture absorption, even when completely submerged in boiling water.

Epoxy Casting Resin Can Be Used at 500 F

An epoxide casting resin that exhibits outstanding physical and electrical properties at elevated temperatures is marketed by *Emerson & Cuming, Inc.*, 869 Washington St., Canton, Mass. Designated Stycast 2662, it has a heat distortion temperature greater

PROPERTIES OF CURED STYCAST 2662

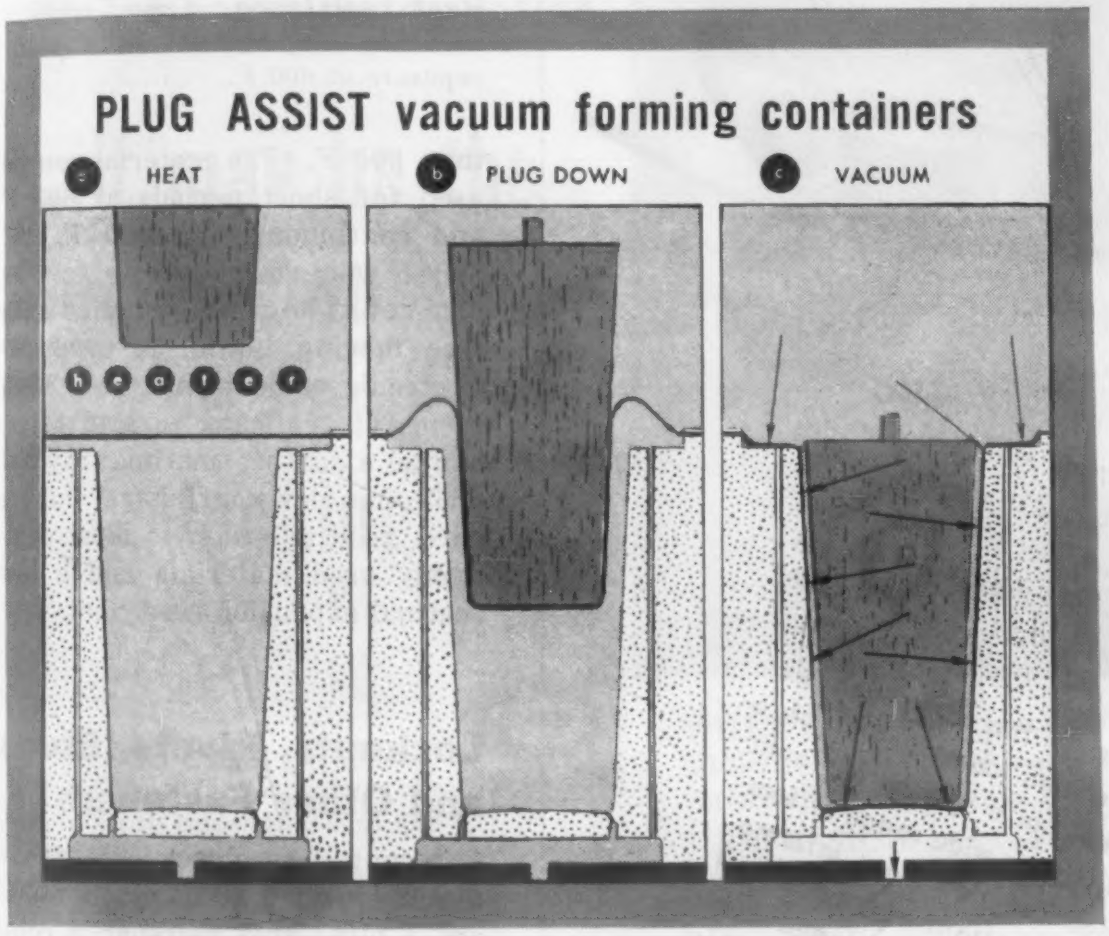
Spec Grav	1.2
Flex Str, psi:	
70 F	14,500
300 F	10,700
Flex Mod, psi:	
70 F	0.65×10^6
300 F	0.43×10^6
Impact Str, ft-lb/in. notch	0.44
Coef of Therm Exp, per F	15.6×10^{-6}
Water Absorp (77 F), % in 24 hr	0.1
Machinability	Good, use carbide tools
Dielec Const (60 cps):	
70 F	3.9
300 F	4.1
Dielec Const (10^6 cps):	
70 F	3.5
300 F	3.6
Dissip Fact (60 cps):	
70 F	0.008
300 F	0.009
Dissip Fact (10^6 cps):	
70 F	0.009
300 F	0.007
Dielec Str, v/mil:	
70 F	420
300 F	370
Vol Resist, ohm-cm:	
70 F	10^{16}
300 F	10^{14}

DOW

Plastiatrics

DOW'S CLINICAL APPROACH TO HEALTHY PLASTICS APPLICATION

"PLUG ASSIST" TECHNIQUE OFFERS NEW ADVANTAGES IN VACUUM FORMING



Increased flexibility in forming offers designers opportunities to make important new uses of plastic sheet

This improved fabrication method for polystyrene sheet products, developed by The Dow Chemical Company and called the plug assist technique, opens new horizons for the progressive designer. With more uniform wall thickness and more even distribution of material in deep-drawn, vacuum-formed parts, plastic sheet applications are increased many times. The added flexibility in design is made possible by a force plug which pre-forms the heated sheet in the cavity prior to drawing the vacuum.

Thorough plastiatrics research is continuously directed toward practical solutions such as demanded for the problem in forming sheet. Shearing or scoring is prevented by the slight air pressure produced between the sheet and the cavity until the plug stops traveling and the vacuum is drawn. The process has been thoroughly tested and appears to lend itself to high-speed automatic forming operations.

The plug assist method is only one of many contributions made by Dow Plastiatrics to every phase of formulation, design and molding for the plastics' industry.

SHEET AVAILABLE FROM MANY EXTRUDERS

In 1952, Dow introduced a method for extrusion of Styron® plastic high-impact sheet. Today, more than thirty extruders offer high-quality, uniform sheet products based on Styron plastic materials. Their names, and the names of qualified fabricators, will be gladly furnished by our nearest Dow Sales Office.

TECHNICAL LITERATURE OFFERED

Several technical bulletins are available at no cost for more detailed information on Styron high-impact plastic sheet for vacuum forming, pressure forming, stamping and embossing. Whatever your problem you may consult Dow with assurance of prompt, confidential help and advice. Write, on your letterhead, to THE DOW CHEMICAL COMPANY, Midland, Mich.—Plastics Sales Dept. PL-435H-1.

AMERICA'S FIRST FAMILY OF POLYSTYRENES

GENERAL PURPOSE
- STYRON 666
- STYRON 665 (Extrusion)
- STYRON 688 (Easy Flow)
- STYRON 689 (Easy Flow)

HIGH IMPACT
- STYRON 475
- STYRON 429 (Extrusion)
- STYRON 777 (Medium Impact)
- STYRON 440 (Heat Resistant)
- STYRON 480 (Extra High Impact)

HEAT RESISTANT
- STYRON 683
- STYRON 700

you can depend on DOW PLASTICS

DOW

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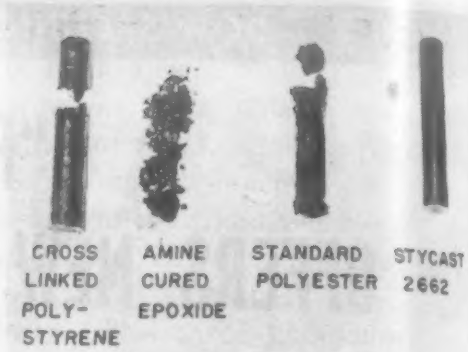


Heat resistance *of new resin is shown by comparative results of 3-hr exposure at 600 F.*

than 500 F. The material can be used for short periods at 600 F and continuously at 500 F. At 500 F volume resistivity is 10^{11} ohm-cm. The resin, supplied as a free flowing liquid, is used for electronic embedments, as a high temperature sealer or adhesive, and as a surface coating. Stycast 2662 has low shrinkage during cure, good adhesion to most commonly used materials and a low thermal expansion coefficient.

Locknuts, Rivets, Studs and Other Fasteners

Among new developments are a double-ended stud, nylon washers, a blind area fastener, a combined rivet and nut, and a high temperature locknut.

1. Weight-saving fastener

A new fastener called Sphere-lock can be used as a substitute for such conventional staking or fastening devices as nuts, bolts and cotter pins. It is marketed by *Bellford Metal Products, Inc.*, 5900 Maurice Ave., Cleveland 27, Ohio, and is expected to find use in aircraft because of the weight saving it provides.

The fastener consists of an insert and mating screw. The hole is drilled and countersunk in the usual fashion. Then an angular counter bore is made to the thickness of the insert. The special tool used for this assures an accurately machined hole with a surface finish value of at least 63

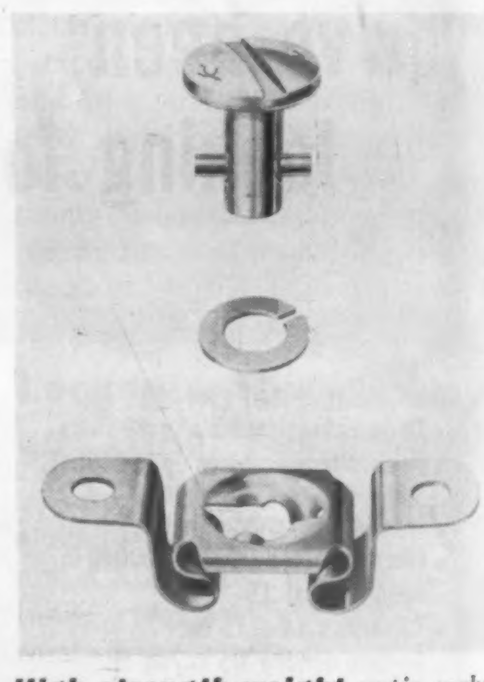
OTHER NEW MATERIALS PRODUCTS

microin. rms. The Spherelock screw is installed and the curved insert is flattened with another special tool locking the screw in place.

The fastener, which locks and disassembles quickly, is supplied to all sizes and standards, including AN, NAS, MS and SAE. Rapid and intermittent temperature changes are claimed to have no effect on its locking ability.

2. Quarter-turn fastener

Small and lightweight, a new quarter-turn fastener provides a high strength-weight ratio particularly adaptable to thin materials and miniaturized equipment. Called Camloc 5F, it is made by *Camloc Fastener Corp.*, 38 Spring Valley Rd., Paramus, N. J. It is offered in many head styles.



***High strength-weight** ratio makes this quarter-turn fastener useful for thin materials and miniaturized equipment.*

3. Self-locking nut

The Jacobson Stop-Nut has a nonmetallic collar that provides a positive locking action in any position on the screw, whether seated or not. It can be reused many times because of the resiliency of the black locking insert of vulcanized fibre. The self-lock-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ing nut is made in steel, aluminum, brass and stainless steel by *Jacobson Nut Mfg. Corp.*, Box 177, Kenilworth, N. J.

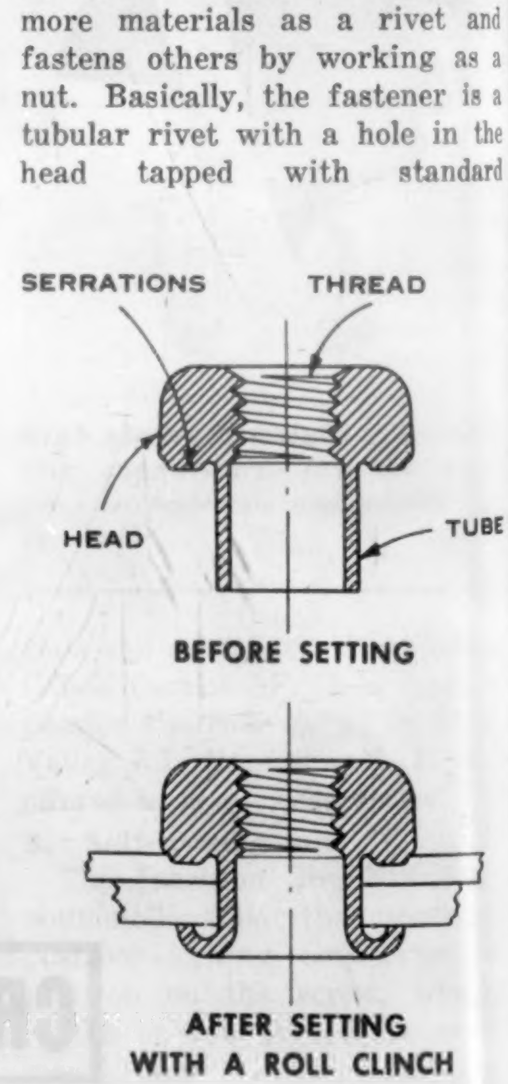
4. Miniature shim spacers

Miniature shim spacers for use with the Kayner series of Kaylock miniature self-locking nuts are marketed by *Thomas Associates*, 4607 Alger St., Los Angeles 39. The miniature shims and nuts offer space and weight savings over types previously used.

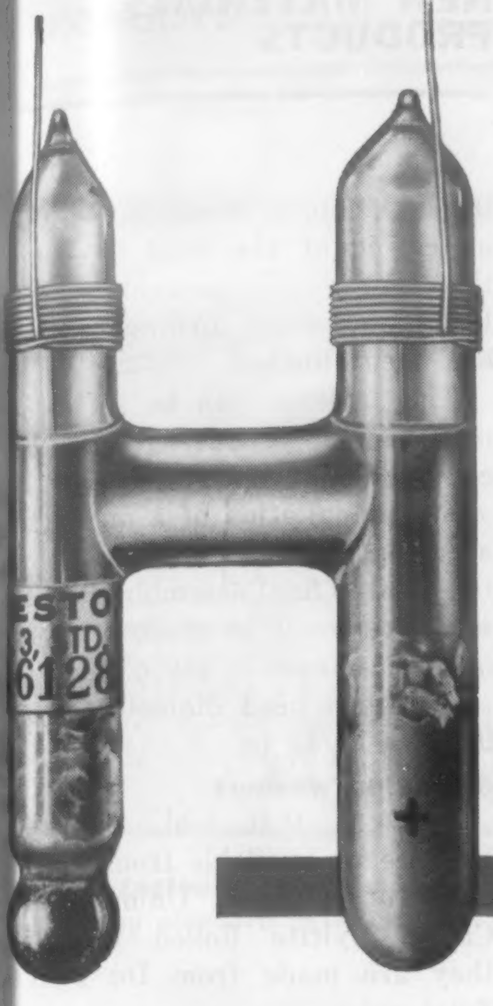
The shim spacers cover all sizes of Kaylock miniature nuts and are supplied in 0.031- or 0.062-gage aluminum. The new TA206 and TA207 series are furnished with an anodized finish per MIL-A-8625.

5. Combined rivet and nut

A fastener that combines the permanence of a rivet with the disassembly features of a nut is made by *Tubular Rivet & Stud Co.*, Wollaston (Quincy) 70, Mass. Called Perma-nut, it holds two or more materials as a rivet and fastens others by working as a nut. Basically, the fastener is a tubular rivet with a hole in the head tapped with standard



***How it works.** Fastener combines advantages of both rivet and nut.*



HOW TO BE SURE A VOLT IS A VOLT...

The Weston Standard Cell Comparator Model 1000, made by Weston Electrical Instrument Corp., Newark, N. J., with associated milliameters, dry cells, main galvanometer, and auxiliary standard cell.*

This H-shaped object, the saturated or "normal" form of the Weston Standard Cell, is the standard reference for electrical measurements. It is essentially a mercury cadmium wet cell hermetically sealed in glass. When kept at 20 degrees C., it maintains its voltage of 1.018636 volts for years. A bank of these cells at the Bureau of Standards in Washington, kept under oil at a constant temperature, is the basic electrical standard of the United States. This, however, is not the cell used by scientists and engineers in their daily work. Since the normal cell must be maintained at a constant temperature for accurate results, the unsaturated or "working" cell, which is portable and is not materially affected by temperature, is ordinarily used.

These working cells must be periodically checked against a bank of normal cells through the use of a comparator system. In the past only a few comparators existed outside the Bureau of Standards. However, the Weston Electrical Instrument Corporation has produced a simplified Standard Cell Comparator which provides the user of working cells, in conjunction with this own bank of temperature controlled normal cells, with an accurate means of standardizing these right in his own plant . . . at a great saving in time, cost and convenience.

THE WESTON COMPARATOR

The Weston Standard Cell Comparator is a specialized potentiometer wherein the voltage of a working cell under test is opposed to that of a normal cell to produce a voltage difference which, when added algebraically to the normal cell voltage, indicates directly the voltage of the cell under test. With a known normal cell voltage as a reference, the Comparator will measure to well within 5 microvolts the open circuit voltage of any cell in good condition.

With an instrument calibrated to such excellent accuracy as this one, it is worthy of note that Weston uses Driver-Harris Manganin wire for critical resistance networks in its system. Says Weston: "The success of the entire circuit, given accuracy of adjustment, depends upon the permanency of the Manganin, and upon its extremely low temperature coefficient of resistance and its low thermal emf to copper".

Your work may or may not need the extreme degree of accuracy that is a prerequisite here. Either way, Driver-Harris has an alloy that can reliably fill your needs. Manganin is only one of 112 special purpose alloys, produced by Driver-Harris. And each of these was originally custom-made . . . produced exactly to the specifications of someone who needed it. Put your specifications in our hands. You will gain the benefits of the 57 years of experience which has developed the largest variety of alloys ever made by any one company.

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SPECIAL PURPOSE ALLOYS SINCE 1899 — D/H — TRADE MARK REG. U. S. PAT. OFF.

Driver-Harris COMPANY HARRISON, NEW JERSEY

BRANCHES: Chicago, Detroit, Cleveland, Louisville, Los Angeles, San Francisco • In Canada: The B. GREENING WIRE COMPANY, Ltd., Hamilton, Ontario

MAKERS OF THE MOST COMPLETE LINE OF ELECTRIC HEATING, RESISTANCE, AND ELECTRONIC ALLOYS IN THE WORLD

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OTHER NEW MATERIALS PRODUCTS

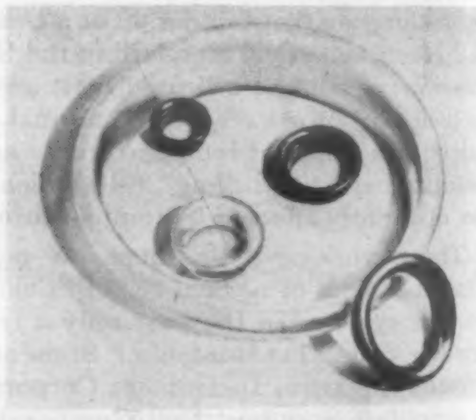
threads. Radial serrations on the underside of the head bite into the workpiece, preventing the Perma-nut from turning, once it has been clinched.

The fastener can be set automatically at production rates on conventional riveting machines. It allows installation of a nut in an area that may be hard to reach or blind after final assembly. Perma-nuts are made in steel, brass or 5056 aluminum in seven standard styles with head diameters from 9/32 to 13/32 in.

6. Nylon washers

Washers that seal, lock and insulate are available from *Nyltite Corp. of America*, Union, N. J. Called Nyltite Rolled Washers, they are made from Du Pont's Zytel nylon.

The washers are slipped over bolts, screws, rivets or nails. When



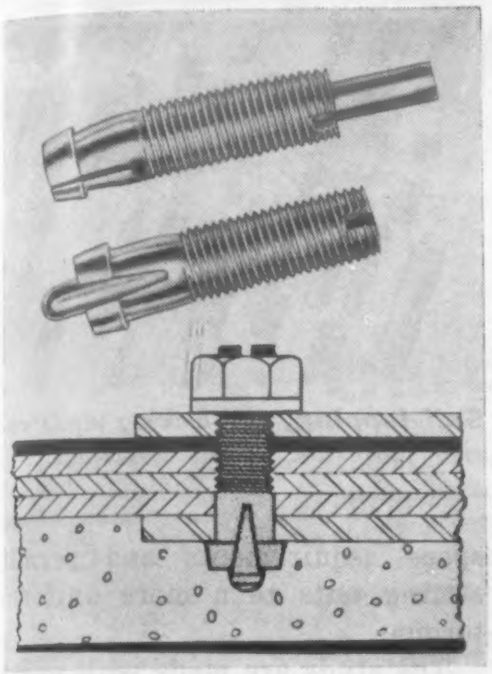
Airtight, leakproof *seals for bolts, rivets and nails are provided by nylon washers.*

pressure is applied, the rolled washer "cold flows" around the fastening device and under the fastener head. Because of the washer's hugging qualities, all space between threads and hole is filled, providing airtight, leakproof seals. The washers also act as a locking device, prevent galling and lessen the effect of vibration.

7. Blind area fastener

Fasteners for bolting parts in areas where standard bolts can-

For more information, Circle No. 597



***Blind fastener** requires 0.377 dia hole, any standard ⅜-24 nut.*

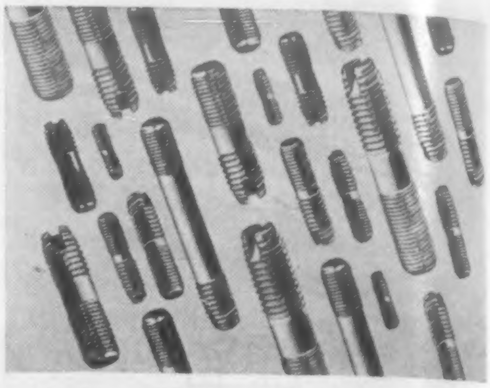
not be inserted have been developed by *Southco Div., South Chester Corp.*, 200 Industrial Highway, Lester, Pa. Called Drivebolt Fasteners, they are inserted from the nut side.

After drilling a 0.377-in. hole, any standard ⅜-24 nut is threaded loosely on the fastener. The Drivebolt is inserted in the hole and the pin driven flush with top of bolt. A blind head is formed automatically behind the hidden side and the nut is then wrenched up tight. A screwdriver may be inserted in the Drivebolt slot to prevent turning, if necessary. Made of cadmium plated steel, the fastener is 2 in. long and consists of bolt and pin. Nuts are not supplied because of the wide variety of styles for various applications.

8. Double-ended studs

New double-ended studs cut their own threads when driven in an ordinary drilled hole and lock securely in the same operation. Known as Schweppe Studs, they are made by *Pheoll Mfg. Co.*, 5720 Roosevelt Rd., Chicago 50. They are claimed to provide more positive locking and resistance to vibration than conventional studs. Compared to bolts, they save on

OTHER NEW MATERIALS PRODUCTS



Self-tapping, *self-locking studs resist vibration, speed assembly.*

space requirements and permit setting nuts to a more uniform torque.

The studs are made with rolled threads in any desired style at each end. At one end a double thread-cutting slot is milled in from opposite sides at an angle toward the end of the stud. The slots are located on opposing radii to provide a positive rake angle on the cutting edge. The depth of the slot is the same as the ASA standard screw slot depth, permitting accurate location for automatic feeding and driving.

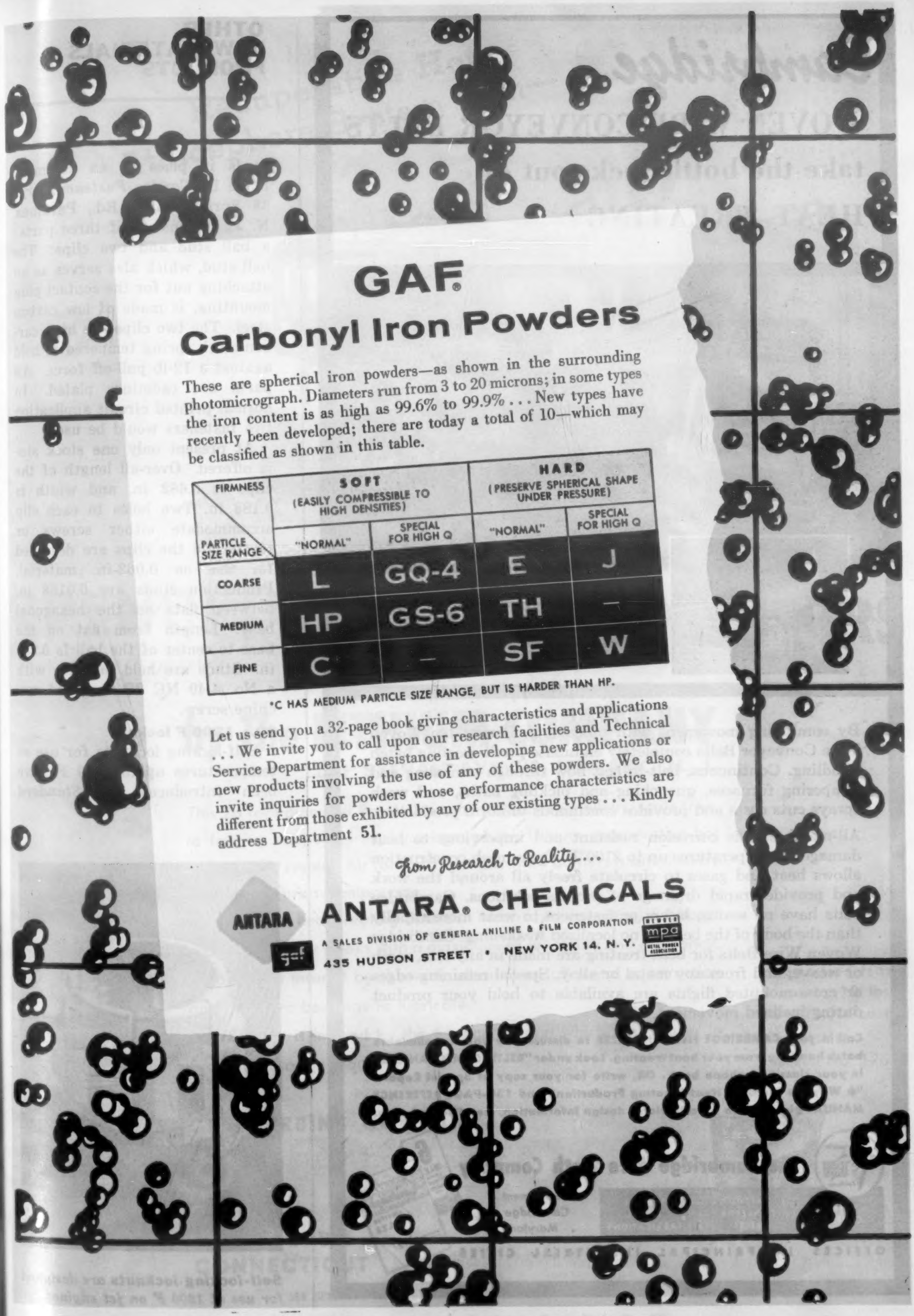
Schweppe Studs can be installed at high speed with any power stud driver. They can be driven in steel, cast irons, aluminum, magnesium and plastics. No special adapters or attachments are required. The studs are reusable. They can be removed from the hole without thread damage and then redriven in any drilled or tapped hole of the same size. Hole tolerance is not critical and no special hole preparation is needed. The studs create their own stability as they cut mating threads in the work material.

Made in alloy steel, high temperature steel, stainless steel or nonferrous metal, the studs are supplied in any length and diameter from No. 4 through 1 in. Finishes can be plain, Parkerized or plated.

9. Printed circuit fastener

A fastening device has been designed for holding printed circuit

◀ For more information, Circle No. 590



GAF®

Carbonyl Iron Powders

These are spherical iron powders—as shown in the surrounding photomicrograph. Diameters run from 3 to 20 microns; in some types the iron content is as high as 99.6% to 99.9% . . . New types have recently been developed; there are today a total of 10—which may be classified as shown in this table.

FIRMNESS / PARTICLE SIZE RANGE	SOFT (EASILY COMPRESSIBLE TO HIGH DENSITIES)		HARD (PRESERVE SPHERICAL SHAPE UNDER PRESSURE)	
	"NORMAL"	SPECIAL FOR HIGH Q	"NORMAL"	SPECIAL FOR HIGH Q
COARSE	L	GQ-4	E	J
MEDIUM	HP	GS-6	TH	—
FINE	C	—	SF	W

*C HAS MEDIUM PARTICLE SIZE RANGE, BUT IS HARDER THAN HP.

Let us send you a 32-page book giving characteristics and applications . . . We invite you to call upon our research facilities and Technical Service Department for assistance in developing new applications or new products involving the use of any of these powders. We also invite inquiries for powders whose performance characteristics are different from those exhibited by any of our existing types . . . Kindly address Department 51.

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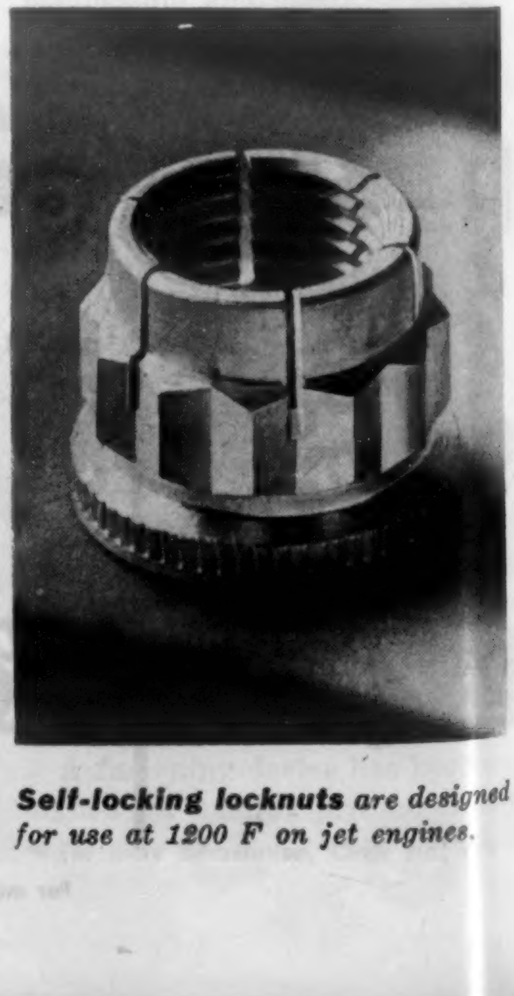
OTHER NEW MATERIALS PRODUCTS

cards in place in an assembly. Made by *Camloc Fastener Corp.*, 38 Spring Valley Rd., Paramus, N. J., it consists of three parts: a ball stud and two clips. The ball stud, which also serves as an attaching nut for the contact plug mounting, is made of low carbon steel. The two clips are high carbon steel, spring tempered to hold against a 12-lb pull-off force. All parts are cadmium plated. In normal printed circuit application two fasteners would be used.

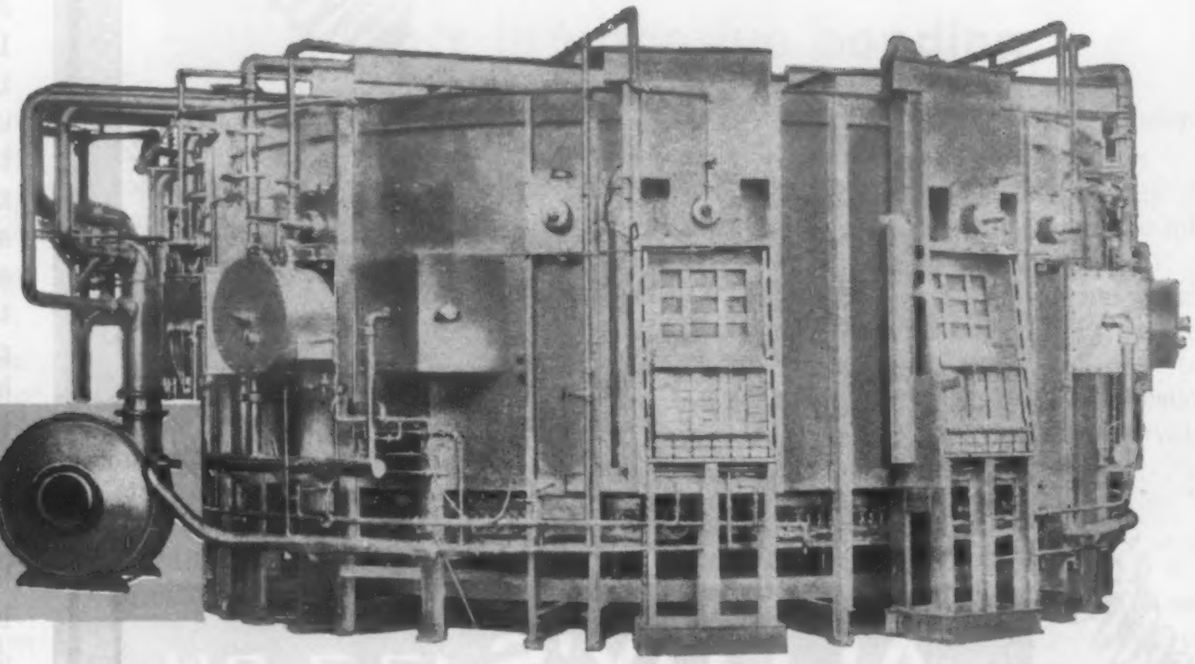
At present only one stock size is offered. Over-all length of the clips is 0.662 in. and width is 0.188 in. Two holes in each clip accommodate either screws or rivets and the clips are designed for use on 0.062-in. material. Production studs are 0.0188 in. between flats on the hexagonal base. Length from flat on the base to center of the ball is 0.281 in. Studs are held in place with a No. 4-40 NC 2B threaded machine screw.

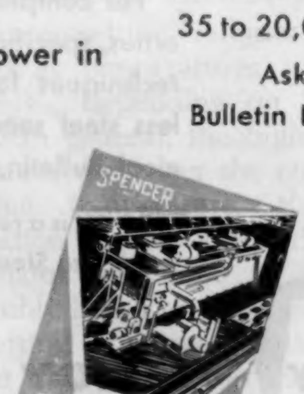
10. 1200 F locknut

Self-locking locknuts for use at temperatures up to 1200 F have been introduced by *Standard*



Self-locking locknuts *are designed for use at 1200 F on jet engines.*





SPENCER
TURBO-COMPRESSORS

OTHER NEW MATERIALS PRODUCTS

Pressed Steel Co., Jenkintown, Pa. Designated 119FW, the nuts are intended primarily for aircraft use. They have the high temperature and corrosion resistance necessary to maintain tensile strength and resist galling and seizing after sustained exposure to high temperature. The one-piece, all metal locknuts, which have a 12 point external wrenching design, can be used in jet engine manifolds, afterburners and similar hot spot applications.

A prevailing-torque type, the locknut has a slotted locking collar that is squeezed in slightly during manufacture. As the nut is threaded on a bolt, the collar segments expand. Spring tension of the segments hold the nut securely in place even under severe vibration. The nuts serve as stop nuts or locknuts and can be reused. Made of AMS 5735 stainless steel and silver plated, they are supplied in standard sizes from No. 10 through ½ in. dia.

Hard Precision Bars for Shafts, Rods, Rolls

Long, round hardened bars for use as guide rods, shafts, rolls, piston rods, axles, etc. are available from *Thomson Industries, Inc.*, Manhasset, N. Y. The material, designated "60 Case," is AISI 1060 steel which has a surface hardness close to 60 Rockwell C and is precision ground to standard diameters. Made with special techniques and equipment, the bars are designed to overcome the problem of producing long, round parts with wear surfaces and without warpage.

Initial standard sizes range from a nominal diameter of ¼ to 4 in. Maximum length varies from 8 to 14 ft depending on diameter. Depth of hardness ranges from 0.040 in. min in the smallest diameter to 0.100 in. min in the largest diameter.

Design data on adhesives

Armstrong

NUMBER THREE

ADHESIVES • COATINGS • SEALERS

Strengthening a metal-to-metal joint

Four basic rules must be kept in mind in order to strengthen any joints to be adhesive-bonded.

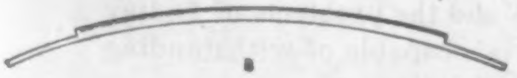
These rules are:

1. Make the bonded area as large as possible.
2. Make the maximum proportion of bonded area contribute to strength.
3. Stress the adhesive in the direction of its maximum strength.
4. Minimize stress in the direction in which adhesive is weakest.

Here's how two of these rules were applied in improving the bond of a metal label to a fire extinguisher.

A

This label was designed for fastening with rivets. The label is flat, has embossed letters, and has holes drilled for riveting. Contact is very poor because of the embossing, resulting in low strength and low resistance to peel or cleavage stresses on the edge of the joint.



B

Remedy

This label was designed for adhesive bonding. The label is pre-curved and has a smooth back for 100% contact. This type of bond will prevent failure when a stress is applied at the edge of the bond with a fingernail or, for example, with some sharp instrument.

1. Bonded area has been made as large as possible.
2. Maximum proportion of bonded area now contributes to strength.

For more information

Write for a copy of "Armstrong Adhesives, Coatings, and Sealers." Armstrong Cork Company, 8010 Dunbar St., Lancaster, Penna.

Factors in adhesive bonding

Most assembly requirements for adhesive-bonded materials include factors of time, heat, and pressure. These vary with the adhesive used and also with the materials bonded.

Time

Two time factors are involved, open time and setting time. Open time is the period of time that can or must elapse between coating the parts and joining them. Some adhesives permit little open time; others must be kept open for intervals ranging from five minutes to twenty-four hours.

Setting time is the period that must elapse before an adhesive bond attains its full strength. Here again the interval may be measured in seconds or weeks, depending upon the adhesive, the materials bonded, and the curing procedure, if any.

Heat

Heat is required in varying degrees in many adhesive applications. Whether one or both surfaces are coated, forced drying of the adhesive film by heating and circulating air is usually desirable and often necessary. The use of heat speeds drying, makes drying independent of weather conditions, and prevents water condensation on the adhesive film.

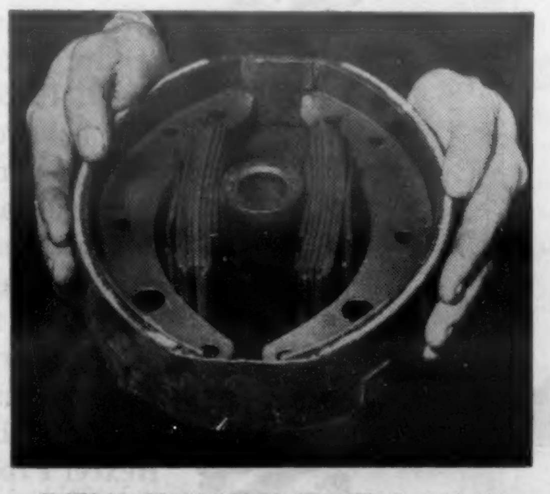


PHOTO COURTESY CHEVROLET-DETROIT GEAR AND AXLE DIV., GENERAL MOTORS CORP.

ADHESIVE-COATED brake shoes and brake bands are assembled on a conveyor line. The brake band is first placed inside a pressure band and against the brake shoe. Pressure springs are then positioned. The assembly is then baked.

Controlled drying also makes it easier to begin assembly when the adhesive film has the right amount of tack, this being the point at which the best over-all bond can be made. Under some conditions, it may be more practical to dry the adhesive film completely and later reactivate it with heat or a solvent.

Special Factors

Thermosetting adhesives, which set by a chemical change in the presence of heat and/or a curing agent, require special assembly techniques. Adhesives of this type are most always used in critical applications where the possibility of bond failure cannot be tolerated—as in the bonding of clutch facings to steel plates. Since such bonds cannot be tested except by destruction, they must be made with extra care and control.

Curing

Some thermosetting adhesives must be cured by chemical reaction at room temperature, the bonded parts remaining clamped for a relatively long period of time. Oven heating of assemblies is quite common. Ovens may be heated by gas, oil, electric, or by infrared units. Forced circulation is required by oven heating in order to insure uniform temperature. The fastest curing time is accomplished by dielectric heat, which cures some heat-set adhesives in a few seconds.

Thermosetting adhesives may be cured at temperatures from 75° to 550° F., depending on the specific type. In general, the higher the temperature, the faster the cure. By controlling temperature, the bonding operation can be speeded or slowed to match the pace of almost any assembly line. Parts bonded with thermosetting adhesives usually can be taken from the presses while still hot.

For detailed information on bonding thermosetting adhesives, see the Armstrong Data Sheet, "Thermosetting Adhesives." It is available upon request. Write for your copy today.

For more information, turn to Reader Service Card, Circle No. 493

CONTENTS NOTED

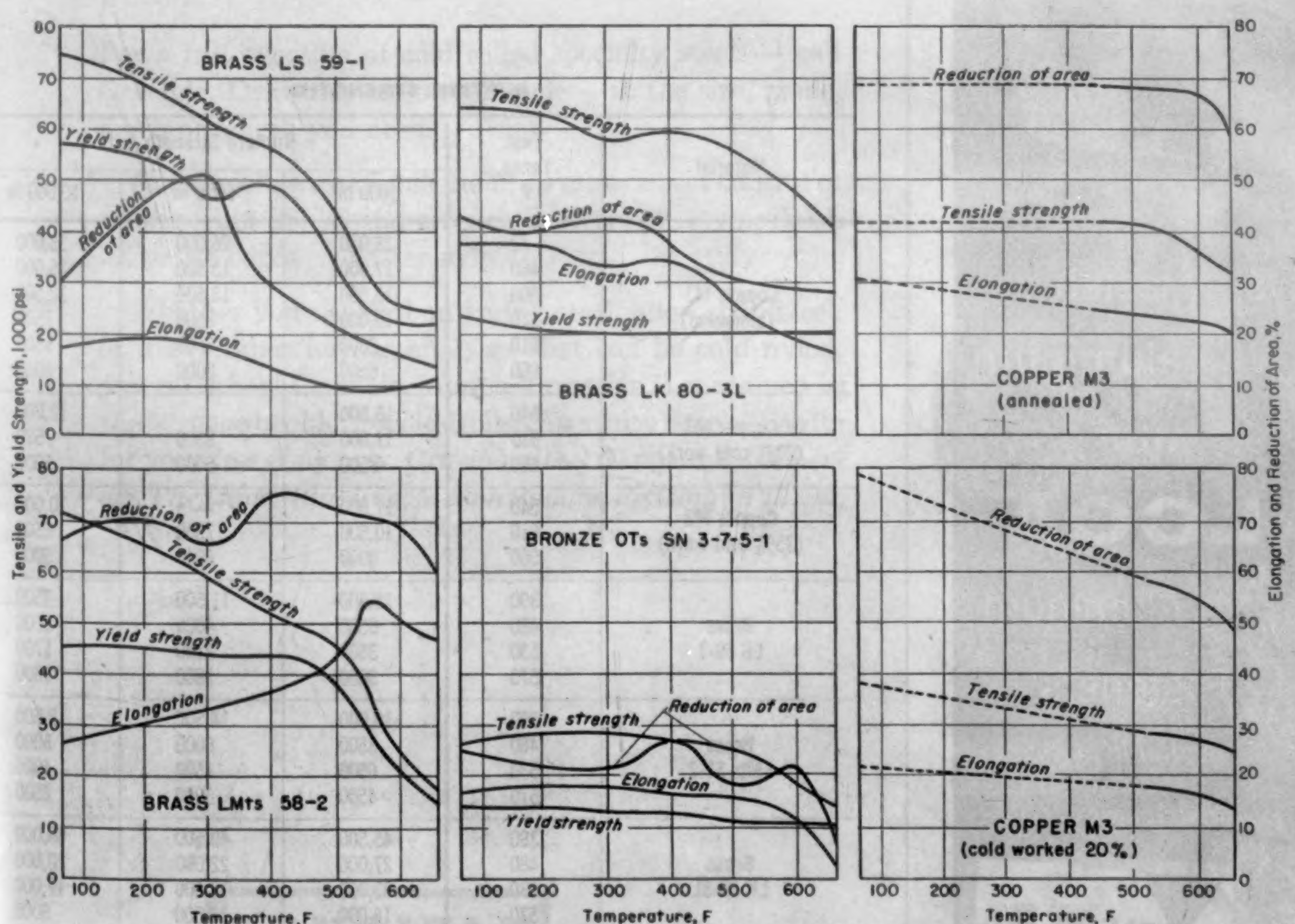
Highlights of current papers, plus a list of recent books and reports.

This Month:

- *Copper alloys at high temperatures*
- *A new memory crystal*
- *Finishes for springs*
- *Predicting gray iron's properties*

How Copper Alloys Behave at High Temperatures

■ Elevated temperature properties of a number of Russian copper-base materials are discussed in an article by A. P. Simakovskii which appeared in a recent issue of *Metallovedenie i Obrabotka Metalloy* (Russian). Chemical compositions (see table) show that the copper is considerably less pure than standard American copper, and that the alloys do not correspond with current American alloys although several approach standard compositions. The alloy designated Brass LS 59-1 is similar to Forging Brass covered in ASTM B 124-55 (Alloy 1) although the lead content is low. The alloy designated LK 80-3L approaches ASTM B 198-52 (Alloy 13A) although the zinc con-



How Strength Properties Vary with Temperature

CONTENTS NOTED

tent is higher, and alloy OTsSN 3-7-5-1 might be considered to lie between Alloys 4A and 4B of ASTM B 145-52.

Short time high temperature properties of these materials are given in a series of graphs. The silicon brass and the leaded nickel bronze retain their strengths well to high temperatures. Copper, tested in the annealed condition and after 20% cold work, retained relatively high strength up to 660 F, and the effect of cold working was not lost at this temperature.

Constant load rupture tests, which are reported, could be plotted as straight lines on log stress versus log time coordinates. Rupture stresses read off such graphs are given in a table. The silicon brass and leaded nickel bronze have the best rupture

CHEMICAL COMPOSITION

Material	Composition, %								
	Cu	Pb	Zn	Fe	P	Si	Mn	Sn	Ni
Copper M3—Drawn tube	99.86	0.01	0.003	0.01	0.037	—	—	0.02	0.014
Brass LS 59-1—Rolled	58.32	1.42	40.25	trace	—	nil	—	—	—
Brass LMts 58-2—Rolled	57.20	nil	40.15	0.08	0.01	—	1.54	trace	—
Brass LK 80-3L—Cast	79.28	0.28	17.35	0.24	—	2.82	trace	—	—
Bronze OTsSN 3-7-5-1—Cast	85.08	3.58	7.35	trace	0.01	nil	trace	3.39	0.63

RUPTURE STRENGTHS

Material	Test Temp, F	Rupture Strength, psi		
		1000 hr	5000 hr	10,000 hr
Copper M3 (annealed)	70	28,000	26,000	25,000
	460	17,000	15,500	15,000
	500	15,500	13,500	12,500
	540	12,000	8500	7500
	610	8000	6500	5500
	660	6500	5000	4000
Copper M3 (20% cold work)	540	15,500	—	12,000
	610	11,500	8500	7500
	660	8500	6000	5000
Copper M3 (35% cold work)	540	17,000	—	10,000
	610	10,500	7500	6500
	660	8000	6000	5000
Brass LS 59-1	390	18,500	11,500	9500
	480	6500	4000	3500
	530	3500	2100	1700
	570	3000	1800	1600
Brass LMts 58-2	390	19,000	14,500	13,500
	480	8500	6000	5000
	530	6500	4500	4000
	570	4500	3000	2500
Brass LK 80-3L	390	45,500	40,500	39,000
	480	27,000	22,000	20,000
	530	23,000	18,500	17,000
	570	14,000	10,500	9000
Bronze OTsSN 3-7-5-1	390	18,500	16,500	15,500
	480	14,000	13,500	13,000
	530	12,000	11,000	10,500
	570	9000	8000	7000

CONTENTS NOTED

MECHANICAL PROPERTIES

Material	Yld Str, psi	Ten Str, psi	Elong, %	Red of Area, %
Copper M3	—	32,000	43.5	69.2
Brass LS 59-1	55,000	75,000	17.8	30.8
Brass LMts 58-2	48,000	72,000	26.2	60.2
Brass LK 80-3	24,000	63,000	36.2	44.3
Bronze OTsSN 3-7-5-1	13,000	27,000	16.7	25.5

strengths of the group.

Although quantitative ductility values obtained during the rupture tests are not included in the article, a number of general comments are given. Cast brass LK 80-3 and wrought brass LMts 58-2 retain appreciable ductility, as measured by elongation and reduction of area, at all temperatures. The bronze alloy loses ductility progressively. Its elongation is only 0.8% upon fracture in 2178 hr at 570 F. Brass LS 59-1 shows an intermediate loss in ductility.

The rupture strength values for copper show that the beneficial effects of cold working are retained for long times at temperatures up to 540 F. However, recrystallization occurs more rapidly at 600 F, and structural changes can be seen in about 10 hr. The strengthening effect of cold working largely disappears in long-time tests at 610 and 660 F.

Ductility of all of the copper specimens decreases during long time testing at temperatures of 610 F or higher, and the cold worked specimens are affected by temperatures as low as 575 F. Typical elongation values are 1 to 4% compared with about 40% after a 2000-hr test at 500 F. Annealing specimens for 1000 hr at 610 F or creep testing under the same conditions using a stress of about 5000 psi fails to cause brittle fracture in a subsequent tensile test at room temperature. A similar loss of ductility during rupture testing is frequently observed in ferrous materials.

Translation and abstract prepared by A. G. Guy, Metallurgical Dept., Purdue University.

G.A.S.H.—New Memory Crystal

A new ferroelectric crystal—G.A.S.H. (guanidinium aluminum sulfate hexahydrate)—discovered over a year ago has been added to the few known materials that have "memory" characteristics. These include barium titanate and ethylene diamine tartrate (EDT), both used primarily as piezoelectric materials to interconvert electrical impulses and mechanical motions.

Though the new ferroelectric crystal was discovered during a search for another piezoelectric material, it exhibits very feeble piezoelectric characteristics. However, its ability to store and later release "bits" of information makes it promising for use in such memory devices as telephone switching systems. In the April issue of *Bell Laboratories Record*, A. N. Holden describes the basic characteristics of the new crystal and compares them with those of barium titanate.

Ferroelectric properties

The peculiar properties of ferroelectric materials depend on an unbalance in their atomic structure. There is an inherent displacement of charge, since the center of gravity of the negative charges in the atomic make-up

CONTENTS NOTED

does not coincide with that of the positive charges. This displacement has a definite direction relative to the structure of the crystal, and a voltage applied to the crystal along that direction tends to change that displacement.

Voltage applied in the direction of charge displacement can be applied in two opposite "senses": in one sense the voltage increases the displacement while it is applied; in the other sense voltage decreases the displacement. However, when voltage is applied in the latter sense displacement never decreases to zero. Instead it suddenly flops over into the opposite direction. In other words, the charges move so that their centers of gravity are reversed. Under alternating voltage a hysteresis loop results.

Whichever way the crystal is pulsed, this electrical history is retained by the crystal until an exploratory pulse reveals—by the size of the current it evokes—which way the voltage was last applied. If the last pulse was in the displacement-increasing direction the exploratory pulse will produce a small current pulse in the circuit that applies the exploratory voltage. If the last voltage pulse was in the other direction, a large current pulse will flow as the displacement flops to the other side again. This is the crystal's only information—the memory of which way the crystal was last pulsed.

How G.A.S.H. measures up

From the above characteristics, some basic requirements for a crystal in a memory device emerge. It should: 1) be stable, retaining its information reliably for a long time; 2) require no inconveniently high voltages; 3) consume only comfortable amounts of power; 4) operate reproducibly in repeated use; 5) provide easy discrimination on read-out; 6) accept and discharge information rapidly on request, or in other words exhibit a short switching time; and 7) be rela-

"FOUR!"

Four? **That's right. Look closely, you'll notice this little golfer represents <u>all four</u> of the services available to designers from Sylvania's Parts Division: (1) Custom-molded plastics; (2) Plated, clad and alloy wire; (3) Metal stampings; (4) Electronic components.**

All of these parts were supplied in quantity to just one major manufacturer during the past year. On many of these items, Sylvania representatives were called in for consultation before parts designs were finalized. Suggestions from an experienced parts producer can often reduce costs, increase efficiency, and assure more uniform production in high volume items.

Manufacturers who insist on the highest degree of quality and efficiency can find Sylvania's 4-way service extremely helpful. For complete details write for the "Portfolio of 4-way Service to Designers." Address Dept. K53S.

SYLVANIA **PARTS DIVISION**

Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania

SPECIAL WIRE · METAL STAMPINGS · MOLDED PLASTIC · ELECTRONIC COMPONENTS

4-way service from one source

For more information, turn to Reader Service Card, Circle No. 540

CONTENTS NOTED

tively unaffected by temperature ranges over which the device must operate.

According to Holden, here is how G.A.S.H. compares with barium titanate:

1. *Voltage* — Operating voltage of G.A.S.H. is approximately the same as that of barium titanate. Twenty volts includes a sufficient factor of safety to operate crystal sections 0.001 in. thick as long as the switching speed required is not too high.

2. *Switching speed*—Under comparable conditions barium titanate switches about 30 times faster than G.A.S.H., which switches in 10 to 100 microseconds. Thus in certain fast-switching applications which barium titanate could handle, G.A.S.H. would require prohibitive voltages to obtain the necessary switching speed. But a fast switching application is usually a frequent switching application and barium titanate sometimes ages with use. That is, under severe operating conditions a few million pulses seriously degrade crispness and intensity of response. G.A.S.H. reacts conversely. It profits from exercise and shows a sluggishness after rest which another period of exercise will cure.

3. *Discrimination ability*—Since the same voltages operate both barium titanate and G.A.S.H., the ability of each material to discriminate between the two directions of displacement can be compared by comparing the ratio of spontaneous polarization to dielectric constant for each material. Spontaneous polarization of G.A.S.H. is 0.35 microcoulombs per sq cm, only about 1/70 that of barium titanate. But the small-signal dielectric constant of the new crystal is only 6, which is about 1/30 that of barium titanate. Thus the theoretical discrimination ratio for G.A.S.H. is about one-half that of barium titanate, which is sufficient for most uses.

4. *Power requirements* — The

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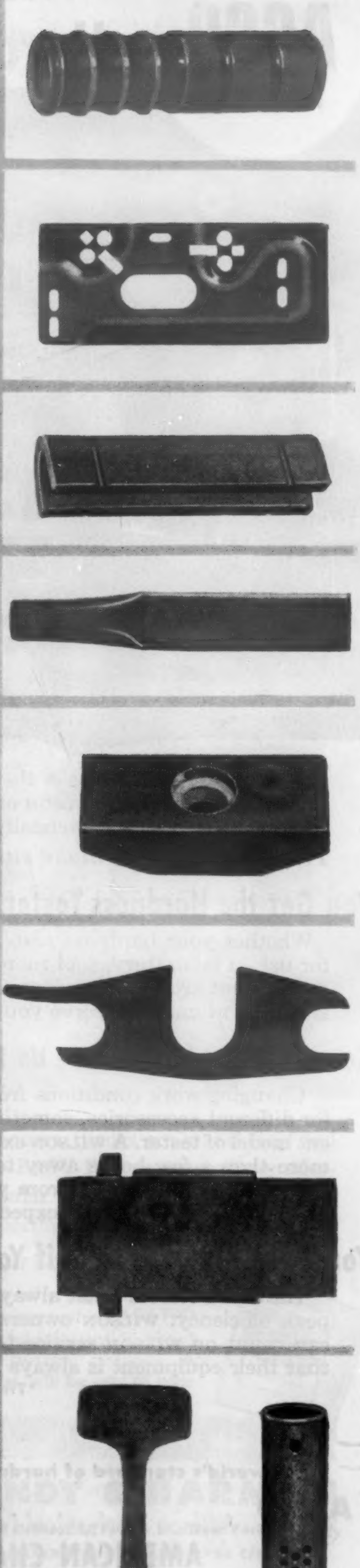

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principal power-consuming operation is the complete reversal of displacement. Power is the product of voltage and displacement, and since the same voltage switches a displacement only 1/70 as large in G.A.S.H., the new crystal requires only 1/70 the power of barium titanate in slow switching if the electrodes have the same area.

5. *Limiting temperatures*—The balance of forces in ferroelectric crystals is usually sensitive to temperature, i.e., above a critical temperature spontaneous polarization disappears. Often this "Curie point" is below room temperature, so that most of the few known ferroelectric materials are worthless to the engineer. Barium titanate loses its polarity at about 250 F. G.A.S.H. remains ferroelectric right up to about 390 F where decomposition becomes too rapid for easy measurement.

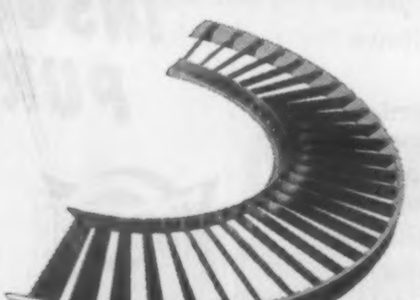
Finishes for Springs: Plated and Nonmetallic

In order to enhance the eye-appeal of springs and to protect them from environmental corrosion, it is frequently necessary to specify some form of decorative or protective coating. An article appearing in the Aug '56 issue of *The Mainspring* (published by Associated Spring Corp.) points out that before deciding what type of finish to use the designer should take into consideration such factors as: Does the spring have to be decorative? How severe will corrosive action be? Is some means of spring identification necessary? Should preplated wire be used to prevent tangling of springs in a plating bath? Only after these factors have been considered can the optimum protective coating be specified.

Metallic coatings

Metallic coatings offer the best protection against rusting and are

Why these stator blades for Curtiss-Wright J 65 jet engines are brazed with EASY-FLO *



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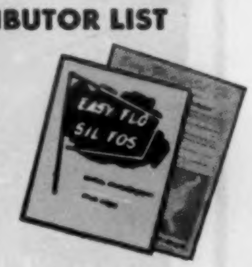

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generally considered to be the most decorative coatings for springs. Because of their economy, cadmium and zinc coatings are perhaps the most frequently used electroplated finishes. Typical recommendations applicable to zinc plated spring materials are outlined in Army Specification 50-0-2C as follows:

Thickness
(Zinc plates)

Class	Min Thickness, in.
GS and GSC	0.001
LS and LSC	0.005
RS and RSC	0.00015

Salt Spray Resistance
(Zinc plates)

Class	Time to Form White Salts, hr	Time to Form Red Rust, hr
GS	—	72
LS	—	48
RS	—	24
GSC	24	96
LSC	24	72
RSC	24	48

Similarly, recommendations applicable to cadmium plated spring materials are outlined by Federal Specification QQ-P-416 as follows:

Type I	Without supplementary chromate treatment	
Type II	With supplementary chromate treatment	
	Class A	0.0005 in. thick
	Class B	0.0003 in. thick
	Class C	0.0002 in. thick

Salt Spray Resistance
(Cadmium plates)

Class	Time to Form White Corrosion Products, hr	Time to Corrode Base Metal, hr
Type I		
A	—	240
B	—	192
C	—	96
Type II		
A	96	336
B	96	288
C	96	192

The letter C following the three classes of zinc coatings denotes coatings that have been given a chromate treatment after plating. The chromate produces an oxide film on zinc or cadmium plated springs which increases the corro-

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sion resistance of surfaces and imparts a high luster.

In general, a cadmium plate on springs provides better resistance to salt spray than a zinc plate. Also, it is possible to color cadmium plated springs by immersing them in a solution that forms a porous oxide, then applying a penetrating and absorbing dye. This coloring treatment facilitates identification of parts and provides high salt spray resistance, similar to that provided by the chromate treatment.

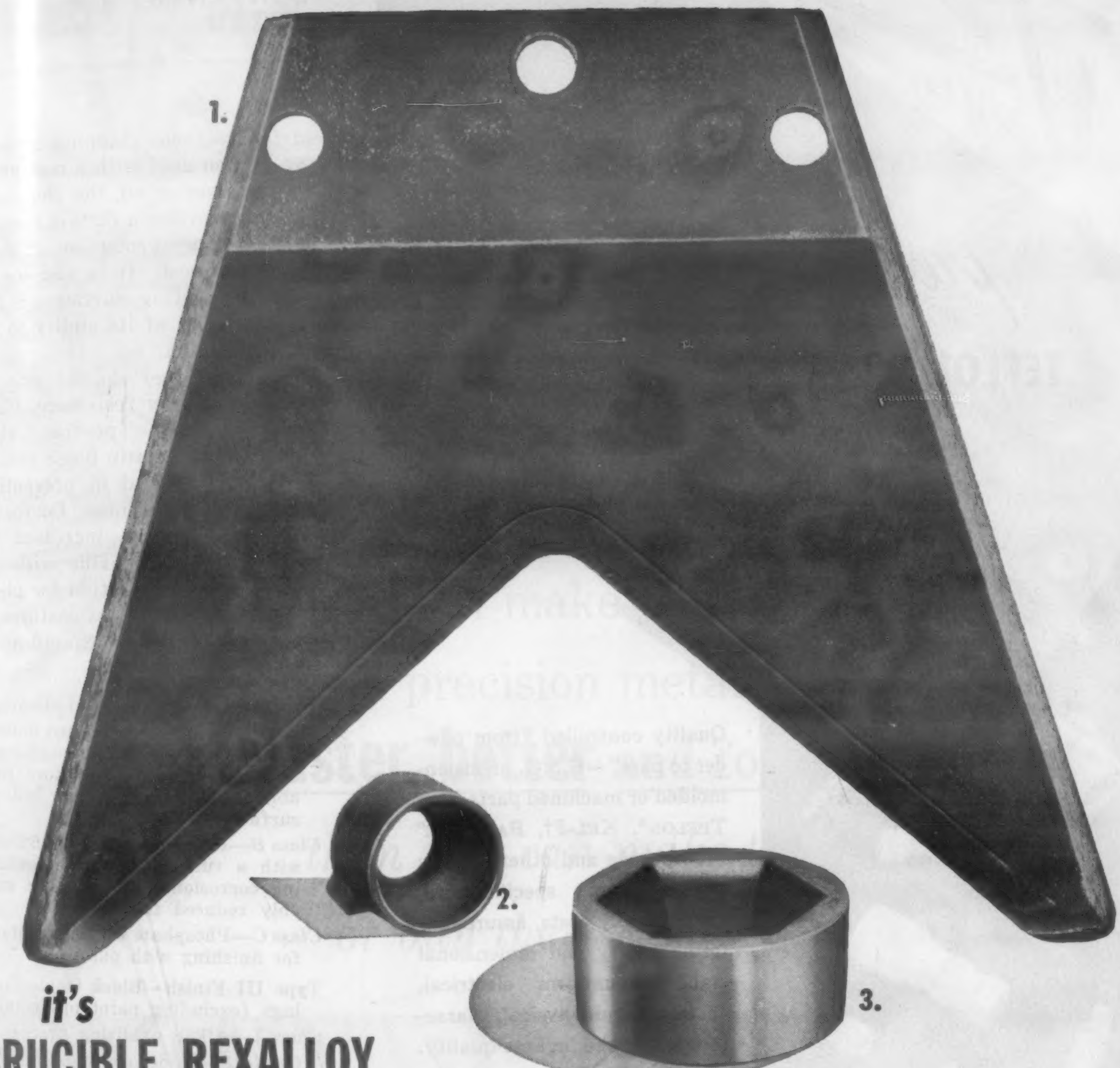
A copper plate is also useful for identification of parts. It offers some rust protection and does not chip or peel under normal use. It is also used as an undercoat for nickel and chromium plate. A chromium plate is used principally to decorate springs for bicycles, motorcycles and other exposed assemblies. When applied to flat springs it also aids in retarding fretting corrosion. Nickel and tin plates are used mainly when it is necessary to protect springs from chemical reaction with gases and certain fluids.

Because hydrogen is emitted during the plating cycle, spring materials must be heated within 2 hr after plating to prevent hydrogen embrittlement. A typical stress relief cycle recommended for cadmium and zinc plates consists of heating at 375 F for 3 hr.

Preplated wire is available for applications where tangling might occur in a regular plating bath. Available with cadmium, zinc or tin plates, preplated wire provides 24 hr salt spray resistance in a 20% salt spray solution.

Nonmetallic coatings

Nonmetallic coatings are not as susceptible to hydrogen embrittlement as are most of the metallic coatings. Phosphate coatings are used principally as an undercoat or bond for paint, or else used alone after being coated with wax or oil. As a paint undercoat these coatings provide a thin porous film which enables a greater quantity of paint to cling to the



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surface without chipping or peeling. When used with a coating of wax, lacquer or oil, the phosphate coating provides a certain amount of salt spray protection at relatively low cost. It is also useful as a lubricating surface on flat parts because of its ability to retain an oil film.

Although they do not provide much salt spray resistance, black oxide coatings provide steel springs with a satin finish that is particularly useful in preventing undesirable reflections. Corrosion resistance can be increased by coating the black oxide with oil.

A typical specification for phosphate and black oxide coatings is provided in Army Specification 57-O-2C as follows:

Type II Finish—Phosphate Coatings
Class A—Phosphate coatings finished with nondrying petroleum oils containing corrosion inhibitors suitable for use on sliding or bearing surfaces.
Class B—Phosphate coatings finished with a rust preventative containing corrosion inhibitors and suitably reduced for application.
Class C—Phosphate coatings suitable for finishing with paint.

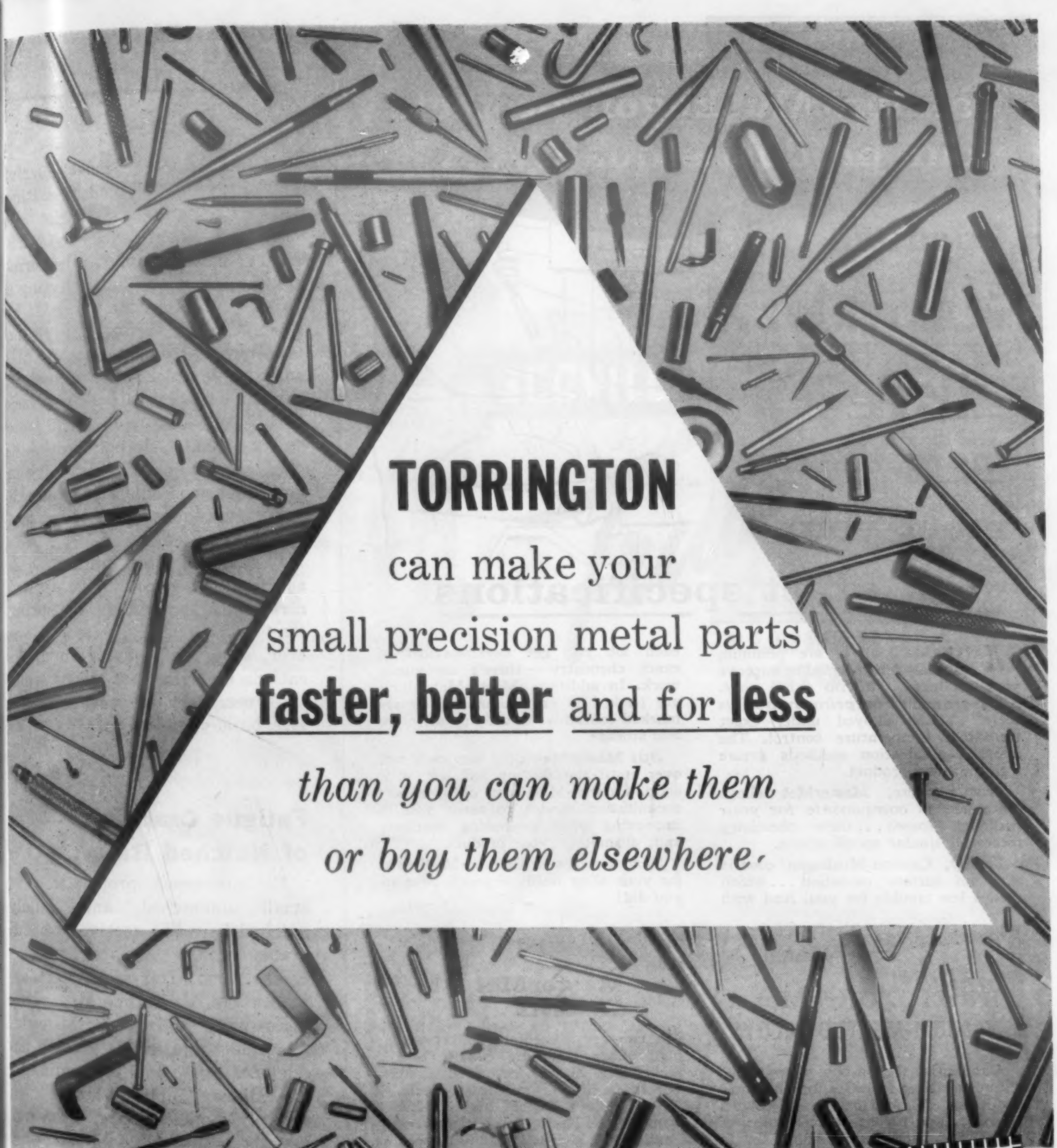
Type III Finish—Black Oxide Coatings (excluding paint products)
Class A—Alkali oxidizing process
Grade 1—Oxide coatings finished with nondrying petroleum oils.
Grade 2—Oxide coatings finished with rust-inhibiting lacquers.
Grade 3—Oxide coatings finished with synthetic resin coatings.
Class B—Chromate
Class C—Fused Salts

Salt spray resistance of the foregoing coatings is as follows:

	Before application of finish, hr	After application of finish, hr
Type II Finish		
Class A	1	24
Class B	2	36
Class C	—	150[a]
Type III Finish		
Class A		
Grade 1	½	2
Grade 2	½	16
Grade 3	½	24
Class B	½	21
Class C	½	24

[a] Applies only to springs without sharp corners.

(continued on p 198)



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Paints offer the most colorful and economical method of coating springs. Painted surfaces not only make identification of parts easier, but also offer fair corrosion resistance. When selecting a paint, consideration should be given to such factors as: 1) the tendency of some paints to dissolve or discolor when placed in contact with hot oil; 2) tendency of brittle paints to flake off from surfaces that have not been phosphate coated, and 3) difficulty in obtaining good adherence and salt spray resistance on flat surfaces with burred edges.

Because of poor hiding characteristics, the use of dye applied directly to the surface of spring steel is somewhat limited. However, dyes are valuable in applications involving hot oil, or when it is necessary to prevent excessive build-up of paint.

Fatigue Cracking of Notched Bars

Fatigue crack propagation in small unnotched and mildly notched bars has received considerable study. Apparently such cracks form after an appreciable percentage of lifetime at a given stress and, at first, grow slowly. At some stage, crack growth accelerates and finally terminates in failure. Similar studies on severely notched bars, however, have been limited.

To investigate the mode of failure, W. S. Hyler, E. D. Abraham and H. J. Grover of Battelle Memorial Institute studied 2024-T4 extruded aluminum rods. Their results are reported in National Advisory Committee for Aeronautics *Tech. Note* 3685.

Rotating bending fatigue tests were run on ¼-in. and 2-in. dia specimens having V-notches of K_t=5.2 and 13.9. Cracking started much earlier with severely notched specimens in the test than with unnotched or mildly notched bars. Deep fatigue cracks were evident

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in the ¼-in. bars at 1000 cycles or less at a stress level of 22,500 psi for which failure might be expected in 200,000 to 1,700,000 cycles. Propagation of these cracks appeared to be very slow for a major part of the lifetime. Acceleration of crack growth shortly before failure appeared to be associated with selected regions of the advancing crack front.

Large diameter specimens had a period of rapid crack growth followed by a marked tapering off of the rate of crack propagation. Presence of compressive residual stresses in the bars may be responsible for this behavior.

Impact Tests and Brittle Fracture

Causes of brittle fracture are still far from being understood, notwithstanding the large amount of work expended in studying the phenomenon. Although the use of notched bar tests has prevented many service failures, the recurrence of accidents, notably those of structures embodying welded plates, raises doubts about the interpretation of transition temperatures. Suggestions of alternative tests have not led to any widely accepted change in the standard method of approaching this problem. Uncertainty in the field derives from the lack of sufficient knowledge of the mechanism of fracture.

In an extensive article published in the June issue of *Journal of the Iron and Steel Institute* (British), C. Crussard, R. Borione, J. Plateau, Y. Morillon and F. Maratray present information on a study aimed at clarifying the fundamental phenomena associated with impact tests.

In the impact test, fracture can be initiated either at the surface (at the root of the notch) or internally. With decreasing temperature, surface fracture is re-

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placed by internal fracture, not abruptly but through a zone in which statistical studies show that both types of fracture can occur. Regardless of the mode of fracture, it is always preceded by plastic deformation, even in the case of brittle specimens where fracture is initiated internally. Evaluation of this preliminary plastic deformation by low temperature tensile tests shows that slight deformation causes internal stresses which embrittle the metal, but heavy deformation subsequently reduces this embrittlement. In impact tests, plastic deformation modifies both the intrinsic brittleness of the metal and the distribution of stresses.

Above the temperature at which there is a change in the method of initiation of fracture, a furthur increase in ductility with temperature can be observed frequently. This increase is accompanied by a change in the appearance of the fracture (relative percentage of "crystalline" and "fibrous" areas) and is associated with a change in the mechanism of propagation of fracture. The shape of the impact energy vs transition curves will depend essentially on the relative position of the "initiation transition" and the "propagation transition." Grain boundaries play a decisive role.

To obtain the maximum safety for industrial structures it appears necessary to determine the propagation transition for a specimen with the sharpest possible notch. Above this temperature, the structure should be completely immune to brittle fracture.

Welding Aluminum to Stainless Steel

A number of aluminum alloys can be inert-gas-shielded tungsten arc welded to aluminum plated stainless steel, with or without

CONTENTS NOTED

adding filler metal. In an article appearing in the July issue of *The Welding Journal*, M. A. Miller and E. W. Mason, of Aluminum Co. of America, discuss the proper method of joint design and preparation to produce welded joints that have satisfactory mechanical properties and are vacuum tight.

Tensile, bursting and fatigue strengths of welded joints between 3004-0 aluminum and aluminum coated Type 304 stainless tubing are approximately the same as those of unwelded 3004-0 tube of the same dimensions. Shear strengths of tube joints between 6061-T6 and aluminum coated Type 304, made with 4034 filler metal, are only a little lower than the typical shear strength of cast No. 43 aluminum alloy.

The effect of post heating on the shear strength of aluminum-stainless steel joints indicates that welded tube might operate safely at temperatures up to 500 F for long time periods without serious loss of shear strength. Available data indicate that aluminum-stainless steel tube joints have adequate resistance to corrosion in many environments.

Ceramic-Metal Friction Materials

Brake energy capacity of brake linings in aircraft and heavy duty equipment has multiplied roughly 34 times in the last 19 years to a recent design value of 50,000 ft-lb per sq in. of wheel, brake and tire envelope area. Such increases in capacity have been realized through improved design of wheels, brakes and tires; better utilization of space; and better materials.

Since only about 20% of brake lining wear results from work done whereas 80% is due to high temperatures during and after braking, attention has turned from organic to inorganic lining

5-1 For more information, turn to Reader Service Card, Circle No. 594

materials. In a paper presented before the National Tractor Meeting of the Society of Automotive Engineers in September, W. H. Du Bois, of Bendix Products, describes the development of lining materials composed of ceramics and metals. Though original application of the materials was primarily in aircraft brakes, successful applications have been made on large commercial vehicles such as tractors, trucks and buses.

Design criteria

Only materials that would not deteriorate under operating temperatures of 2000 F were investigated. Bendix concluded that a good friction material should have all of the following characteristics: 1) adequate mechanical strength through all operating temperatures; 2) temperature and thermal shock resistance; 3) high heat absorbing capacity; 4) high and consistent coefficient of friction; 5) low wear rate; 6) smooth engaging characteristics; 7) compatibility with mating surfaces, i.e., minimum galling, wear or heat checking; 8) nonfusibility with opposing surface; and 9) noncombustibility.

Bendix's materials, called Cerametalix, employ the inherently brittle ceramic materials as the frictional elements and as partial insulation to protect the metallic matrix from high surface temperatures. The metallic matrix provides mechanical strength and conducts heat away from the rubbing surface. The combination of metal and ceramic provides the ideal wearing surface. How these ceramic-metal materials compare with the design criteria is discussed in some detail by Mr. Du Bois, and his discussion is summarized below.

Performance

Mechanical strength—High temperature strength is often the most critical problem because stresses are normally high and a wide temperature range is encountered. Also, strength is normally obtained by sacrificing de-

sirable friction properties. Cerametalix linings minimize the strength problem by mechanical design and by use of a metallic matrix. The high temperature strength of the metal-ceramic combination is superior to that of the metal alone.

Heat and thermal shock resistance—No structural change occurs in these linings due to mean temperatures because the lining is heat treated during processing at temperatures higher than the soaking temperatures normally encountered during use. Although some surface damage may occur due to high localized temperatures, it is not permanent damage such as would jeopardize future operation of the lining. Surface changes due to high temperatures normally improve friction stability and wear properties.

Since the metal is the continuous or bonding phase, thermal shock properties are excellent. Surface cracks occasionally occur in the glaze, but no structural damage or detrimental effect on lining life has been detected.

Heat absorption—The heat absorbing properties of ceramic-metal linings are superior to those of organic-bonded linings, since their specific heat, specific weight and thermal conductivity are all higher. Conventional metallic facings have similar heat absorbing properties, but their limited heat resistance reduces their effectiveness as a heat reservoir.

Coefficient of friction—A high coefficient of friction is desirable in most linings, and a consistent coefficient is essential for good performance in any clutch or brake. The combination of the proper ceramic friction material and the heat resistance of the resultant linings provides a consistent coefficient of friction with increasing temperatures. Fade characteristics at high temperatures are said to be superior to those of any of the conventional organic or metal powder lining materials. In some applications ceramic-

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metal linings have been found to have lower friction values at high normal loads (above 150 psi). However, in most such cases the lower coefficient has been corrected by a change in liner composition.

Coefficients of friction of ceramic-metal lining materials in general tend to decrease with repeated application due to formation of a glaze on the surface. This problem can be eliminated by altering composition to effectively control glaze formation.

Wear rate—According to Du Bois, actual experience has shown Bendix's linings to have a wear life 3 to 10 times that of conventional linings. This improved life is attributed to: 1) high temperature strength; 2) glaze formation; and 3) the combination of hard, wear resistant ceramic particles imbedded in the metallic matrix.

The surface glaze on the lining affects all friction properties, but is particularly effective in reducing wear. Compositions have been developed that will promote glaze formation and control its effects on friction properties for most of the conditions encountered in clutches and brakes. Wear rate is also controlled to a large extent by the amount of ceramic material incorporated in the lining. Use of almost any hard, refractory ceramic material will reduce wear. The major accomplishment is to reduce wear and at the same time obtain the other desirable friction properties.

The ceramic material and additives used to control the glaze formation can be adjusted to control torque velocity characteristics, which have an important bearing on engaging characteristics. Torque velocity characteristics of ceramic-metal lining materials are affected by different operating conditions, but in most cases a uniform torque with decreasing velocity can be obtained by proper selection of lining composition.

Engaging characteristics—The

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rigid nature of ceramic-metal linings, particularly at higher temperatures, together with irregularities at the friction surface, may promote engaging characteristics that are more aggressive than those of organic bonded linings. Good engaging characteristics can be obtained by control of torque characteristics through changes in composition and by proper design.

Mating—Good mating surface conditions imply no galling or transfer of lining material, minimum and uniform wear, and minimum heat checking. Galling of opposing surfaces by metal-ceramic linings has been largely eliminated by development of compositions that glaze at the surface and prevent transfer of the matrix metal to the opposing surface. Because of this hard glaze, opposing surface materials should be selected with care. In general, high strength cast iron and hardened steel have been found to be more desirable than lower strength materials.

Fusibility — The high ceramic content and good heat resisting properties of ceramic-metal linings eliminate any tendency for the material to weld or fuse to the opposing surface, regardless of overload or abuse in service.

X-ray Diffraction Yields Basic Data on Metals

Basic studies of metal fatigue and corrosion will benefit from recent work conducted at the National Bureau of Standards on the distribution of stresses between crystals. X-ray diffraction studies of changes in lattice spacing showed that the magnitude and direction of the principal stresses can be computed for a certain loading condition even though the elastic limit has been exceeded.

Commonly used metals are composed of a large number of small crystals. When a stress is applied to such an aggregate, the behavior

CONTENTS NOTED

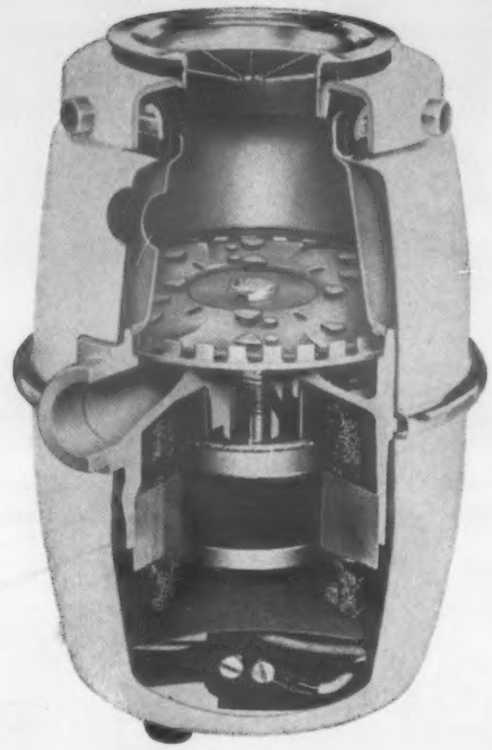
of individual crystals depends on the orientation of the crystal axes relative to the direction of stress. If the crystals are oriented randomly, the individual effects are averaged and the metal acts in a nearly homogeneous manner. However, the distribution of stress is not uniform from one crystal to the next. Measurement of these individual stresses is important to understand such phenomena as fatigue and stress corrosion which are restricted in their early stages to a single crystal or to the boundary between crystals.

Working with low alloy steel, H. C. Vacher, R. Liss and R. W. Mebs, of the Metallurgical Div., measured lattice strain in 17 directions, both under load and after release of load, successive loads being of increasing magnitude. In addition to determining that the magnitude and direction of the principal stresses can be computed from changes in lattice spacing, they found that the experimental results do not agree with current residual stress theories. They suggest that the balancing of residual strains is supplied by stresses in material in which the crystal lattice is so distorted that it does not scatter X-rays coherently. Such material might be found at grain boundaries or in slip bands.

Modified Polyethylene in Chemical Equipment

The elastomeric polymer Hypalon (Du Pont's trade name for chlorosulfonated polyethylene) is highly chemical resistant and has exceptionally good high temperature resistance. (See M&M, May '53, p 104.) It is particularly well suited for the lining and corrosion proofing of chemical equipment. In an article in the May '56 *Corrosion*, R. McFarland, Jr., of Hills-McCanna Co., discussed Hypalon's properties in relation to its use as a construction material for chemical equipment.

According to McFarland, the



For more information, turn to Reader Service Card, Circle No. 416

CONTENTS NOTED

chlorine makes the polymer exceptionally tough, but workable, by reducing crystallinity and stiffness. It produces oil and chemical resistance of a much higher order than that of conventional polyethylene. The sulfonyl groups can be used to vulcanize the polymer with a metallic oxide-organic acid system and an accelerator to give a tough, high strength, elastomeric vulcanizate. Hypalon stocks have inherently good tensile characteristics without filler additions; however, conventional fillers such as carbon black can be used.

The formulation with the highest temperature resistance is cured with magnesium oxide and lead oxide. It withstands limited service at 350 F, can be used for several months at 250 F, and can be used continuously at 200 to 220 F. The major limitation of this high temperature formulation is the difficulty in fabricating complex molded pieces with inserts.

Physical properties of Hypalon include tensile strength of 2300 to 2600 psi, elongation of 300 to 375%, modulus at 100% elongation of 800 psi, hardness of 65 to 70 Shore A, and compression set of 30% (method A). These physicals can be considered exceptional in the light of the chemical resistance of the material. Low temperature and abrasion resistance properties and flex life of Hypalon are good. Brittle point of loaded stocks is below −40 F and that of unloaded stocks below −80 F.

Hypalon has exceptional resistance to oxidation, weathering, ozone, acids and solvents. It is particularly resistant to strong oxidizing materials such as chromic acid, nitric acid, chlorine solutions, chlorine dioxide and sodium hypochlorite. It also has excellent resistance to hydrochloric, sulfuric, phosphoric, acetic and other acids and acid salts. Although it is not recommended for handling hydrocarbon and chlorinated solvents, it can be used advantageously for handling mixtures of

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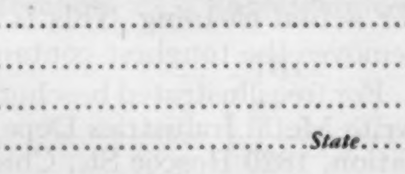

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CONTENTS NOTED

such solvents and acid reagents where some swelling of the part can be tolerated.

The material should find considerable use in tank linings, protective skirts, hose packing, valve diaphragms and similar parts used in contact with corrosive materials. Some developmental work has been done on use of the material as a lining for metal tanks, fittings and valves. The main problem is one of shrinkage and proper adhesion to the metal surface. Reports indicate that shrinkage can be minimized by incorporation of low molecular weight polyethylene at the compounding stage. Considerable progress has been made also in the compounding of cements to obtain the desired adhesion.

Solution coatings of chlorosulfonated polyethylene can be applied to rubber or other nonmetallic surfaces to provide special maintenance coatings. These coatings can also be applied to metal, the best adhesion being obtained by modifying the formulation with phenolic resin and using a chlorinated rubber primer.

Hypalon 20, which recently came on the market, is said to be a considerable improvement over the original material. It has better tack properties and less nerve. It can also be blended with natural rubber or GR-S where improvement of chemical and age resistance are desired.

(Books on p 218)

Where Can You Use Glass?

Next month's 16-page manual should answer this question. It details the broad range of properties available in various commercial glasses and explains which glasses are available in standard production quantities. It also gives you basic information on how to use the properties of glass in your product, and how to design most economically.

For more information, Circle No. 537

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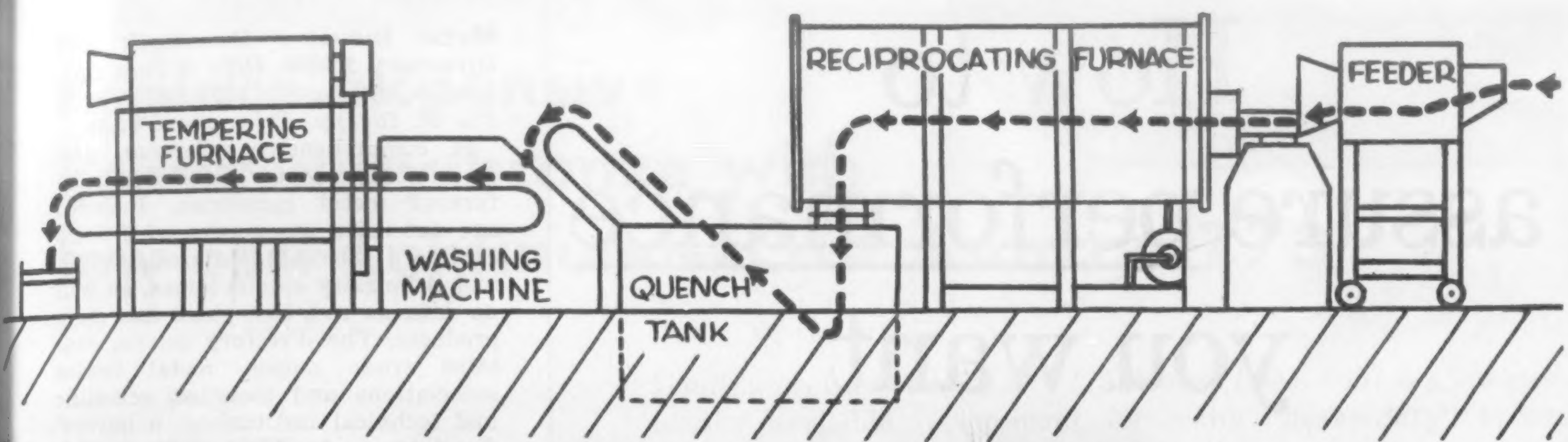

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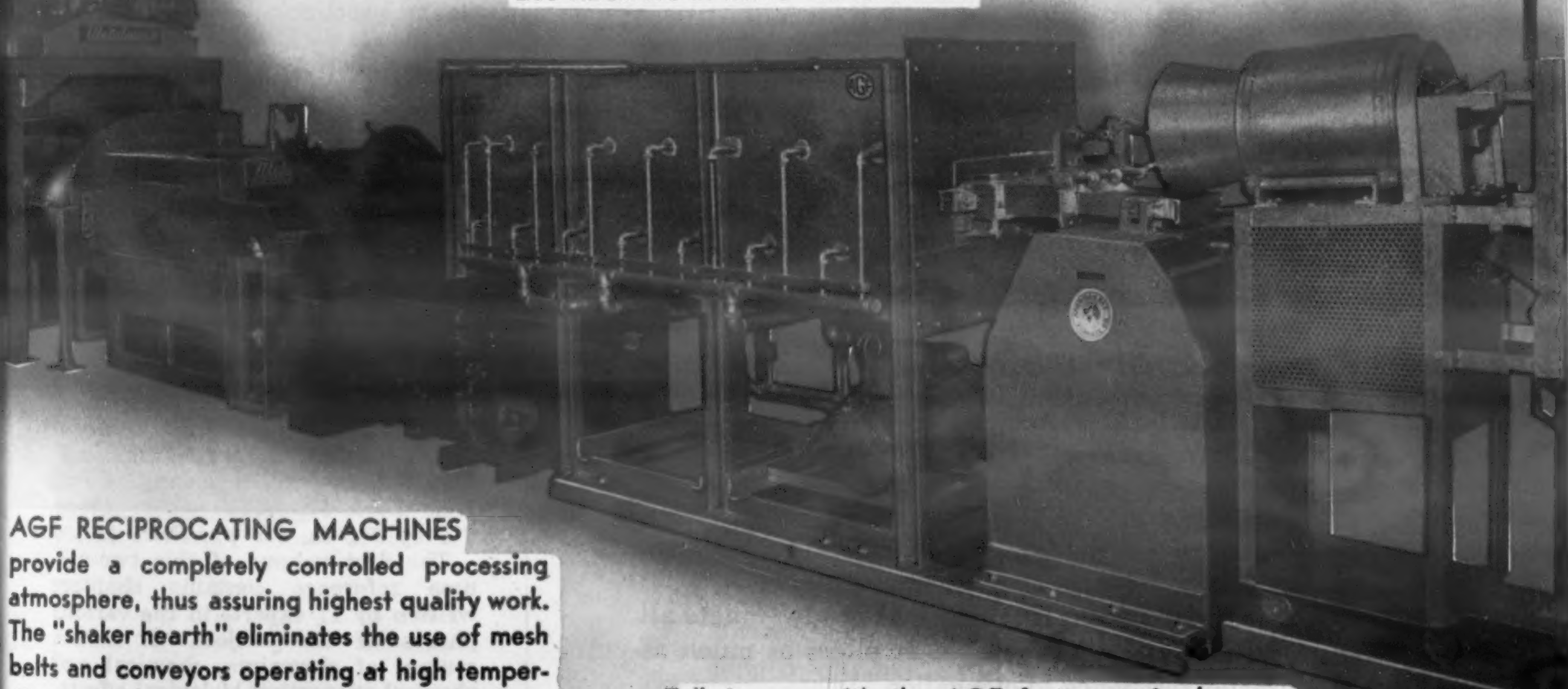

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CONTENTS NOTED

BOOKS

Metal Industry Handbook and Directory 1956. *Iliffe & Sons Ltd., London, England. 1956. Paper, 6 by 8¾ in. 508 pp. Price about $2.30.*

A comprehensive reference, now in its 45th year, for the British nonferrous metal industries. Included are extensive summaries of British Standard Aircraft Material, D.T.D. and Admiralty specifications, as well as data on rod, bar, sheet and strip products. The directory section contains trade names, metal trades associations and societies, scientific and technical institutions, a buyers' directory, and address lists.

1955 Vacuum Symposium Transactions. *Committee on Vacuum Techniques, Inc., Box 1282, Boston 9, Mass. 1956. Cloth, 8¾ by 11¼ in. 101 pp. Price $10.00*

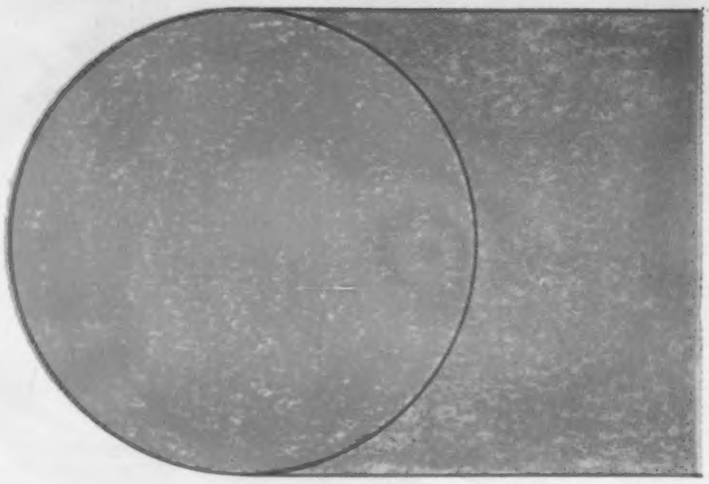
The symposium was held in Pittsburgh at the Mellon Institute in October 1955 and was attended by 284 members. There were seven papers on fundamental developments in vacuum technology, four on applications and processes, and six on methods and techniques for obtaining high vacuums. Three papers dealt with standards and nomenclature. The book is well illustrated with photographs, graphs and tables.

Chromium. Volume I—Chemistry of Chromium and Its Compounds. American Chemical Society Monograph No. 132. *Edited by Marvin J. Udy. Reinhold Publishing Corp., New York 22, N. Y. 1956. Cloth, 6¼ by 9¼ in. 450 pp. Price $11.00*

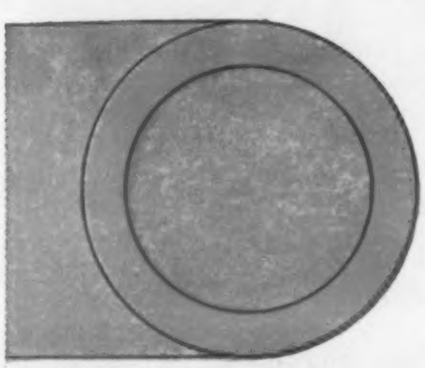
The first volume of this two-volume reference contains chapters written by 17 experts in the various phases of the subject. It covers sources of chromium, chemical and physical properties, biological effects, production of chromium chemicals and their industrial applications. Containing the latest data and knowledge on chromium, the book is illustrated with photographs, numerous charts, tables and lists of references.

Resistance Welding, Theory and Use. *Prepared by Resistance Welding Committee, American Welding Society. Reinhold Publishing Corp., New York 22, N. Y. 1956. Cloth, 6¼ by 9¼ in. 163 pp. Price $4.50*

Written by authorities, the material in this handbook is presented so that it can be understood despite lack of previous knowledge of the subject. It will be equally useful to more experienced designers, engi-



Replace expensive heavy-duty bronze with low-cost Continuous-Cast Asarcon 773

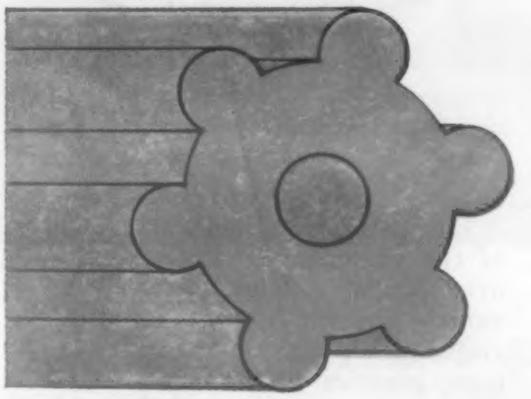


Continuous-Cast ASARCON 773 Bronze (SAE 660) is a low-cost, readily available replacement for many "heavy-duty" bronze parts, especially where wear resistance is essential.

While sand-cast SAE 660 has a yield strength of 19,000 psi, the same alloy, continuously cast by ASARCO, has a yield strength of 27,000 psi.

How Continuous-Cast SAE 660 compares with sand-cast 80-10-10 and SAE 62 is shown in the table below:

Alloy	Tensile Strength	Yield Strength	Brinell Hardness
80-10-10 (Sand-cast)	35,000 psi	17,000 psi	62
SAE 62 (Sand-cast)	48,000 psi	20,000 psi	65
ASARCON 773 (SAE 660)	44,000 psi	27,000 psi	72



These extraordinary advantages in physical properties enable engineers to use ASARCON 773 in a variety of applications where more expensive alloys are now being specified . . . even aluminum and manganese bronzes under certain conditions.

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- It is available in rods, tubes and "extruded shapes" in diameters from ½ inch to 9 inches and in lengths up to 105 inches.
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- It is more easily machined than most of the heavy-duty alloys it is used to replace.

ASARCO continuously casts many other bronze foundry alloys. If you want to know more about these unusual metals, call your nearest ASARCON distributor or write directly to us.

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IN CANADA: Federated Metals Canada, Ltd., Toronto and Montreal

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CONTENTS NOTED

BOOKS

neers and shop personnel because it reviews the fundamentals of resistance welding. Full details are given on all six resistance welding processes, machines, controls and electrodes, welding of different metals, weld quality, inspection and testing.

Sodium. Its Manufacture, Properties and Uses. American Chemical Society Monograph No. 133. *Marshall Sittig. Reinhold Publishing Corp., New York 22, N. Y. 1956. Cloth, 6¼ x 9¼ in. 540 pp. Price $12.50.*

This book contains information on the manufacture, handling and use of sodium with a critical coverage of its physical chemical and thermodynamic properties. One hundred and fifty line drawings and photographs of equipment and actual sodium handling operations are shown. More than 2000 references give ready access to the entire body of published periodical and patent literature on the material. Mr. Sittig is the author of 13 technical articles on sodium.

The Condensed Chemical Dictionary. *5th Ed., Revised by Arthur & Elizabeth Rose. Reinhold Publishing Corp., New York 22, N. Y. 1956. Cloth, 6 x 9 in. 1220 pp. Price $12.50.*

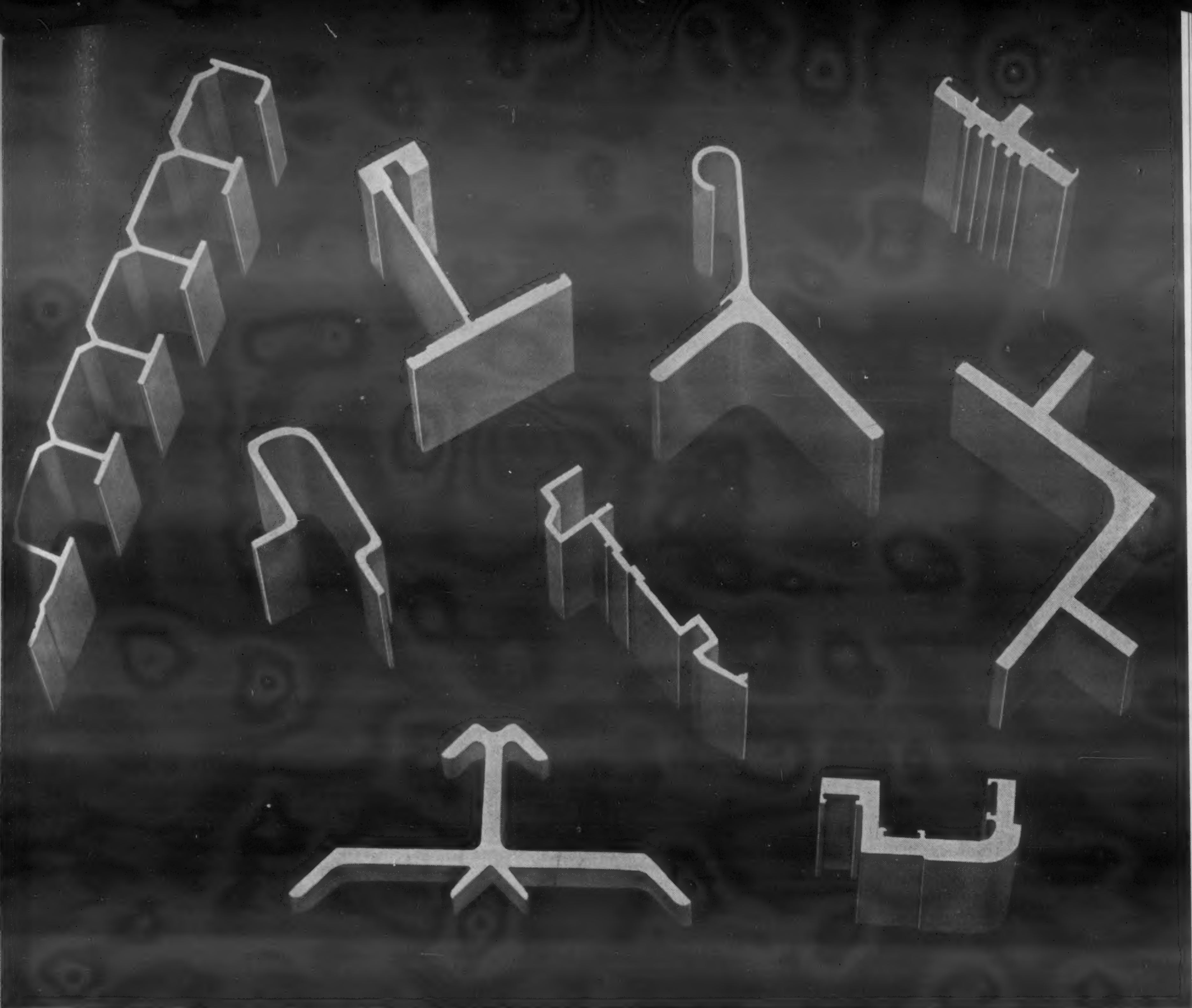
This thumb-indexed fifth edition of the Chemical Dictionary contains over 30,000 entries. Adhesives, ceramics and glass, engineering materials, metals and alloys, organic coatings, plastics and rubber, and textiles are among some of the subjects covered. Data on the chemical and physical properties of chemicals and raw materials; newest information on containers, shipping regulations and safety instructions; and new uses of chemicals in nuclear energy, chemotherapy and other fields of current interest are also given. In addition, many new cross references help clarify the confusion often associated with chemicals and their synonyms.

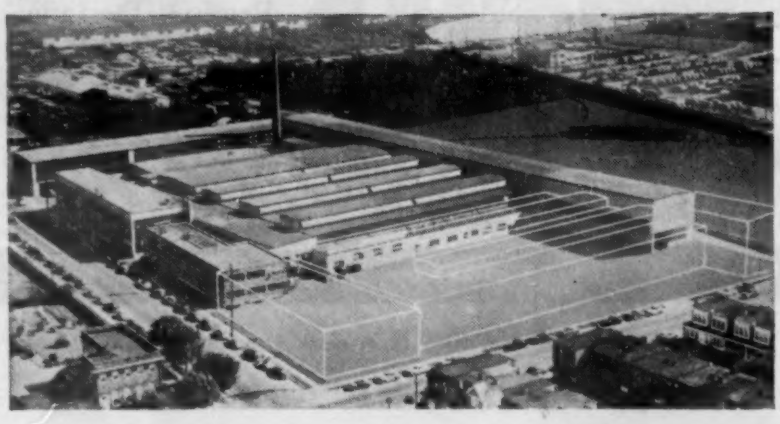
(Reports on p 224)

Plating Powder Parts

Coming in November

Results of a comprehensive investigation of the performance of electroplates on iron powder parts. Includes a list of recommended baths.





CONTENTS NOTED

REPORTS

High temperature alloys Investigation of the Influence of Boron and Titanium on the High-Temperature Properties of Cr-Ni-Mo-Fe Austenitic Alloys. *C. L. Corey and J. W. Freeman, Univ. of Michigan, for Wright Air Development Center. Dec 1954. 72 pp, photos, graphs, tables. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. $2.00 (PB 121101)*

Boron alone was effective in increasing creep-rupture strength at 1200 F. Far less boron was required in the presence of 0.6% titanium. Response to hot-cold work as measured by creep-rupture strength at 1200 F was increased by boron. Again lesser amounts of boron were required in the presence of titanium. Strengths were about the same, however, in both cases. Boron additions also appreciably increased elongations and reduction of area in creep-rupture tests.

Stiffness of titanium INCREASING THE RATIO OF MODULUS OF ELASTICITY TO THE DENSITY OF TITANIUM ALLOYS. *W. H. Graft, D. W. Levinson and W. Rostoker, Armour Research Foundation. Nov 1955. 74 pp, photos, dwg, diags, graphs, tables. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. $2.00 (PB 121151)*

Titanium and its alloys exhibit lower elastic moduli-to-density ratios than other competitive metals. This work showed that: 1) an alloy of improved elastic modulus-to-density ratio must be predominantly alpha phase and 2) alpha phase alloyed with aluminum shows markedly increased elastic modulus. As an alternative, modulus-to-density of unalloyed titanium may be increased by addition of carbon or boron as dispersions of carbides and borides.

Brittle ceramics BEHAVIOR OF BRITTLE-STATE MATERIALS. PART II. *O. K. Salmassy, E. G. Bodine, W. H. Duckworth and G. K. Manning, Battelle Memorial Institute. June 1955. 161 pp, photos, dwgs, diags, graphs, tables. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. $4.25 (PB 121002)*

Principles for selection, evaluation and design of brittle-state materials—primarily brittle ceramics—were studied from a statistical or probability viewpoint. Factors influencing fracture of brittle ceramic materials included size, stress state, strain rate and delayed fracture, temperature and flaws. Weibull's statistical

For more information, Circle No. 598 >

theory of strength predicted effect of size and effects observed in simple stress states of tension, bending and torsion. It was not adequate for predicting effects of combined stress.

Barium titanate aging AGING IN BARIUM TITANATE CERAMICS. *D. Berlincourt, Brush Laboratories Co. Mar 1955. 23 pp, graphs. Available from Library of Congress, Photoduplication Service, Publications Board Project, Wash. 25, D. C. Film $2.70, stat $4.80 (PB 119933)*

Titanium extrusions THE COLD EXTRUSION OF TITANIUM. *A. M. Sabroff and P. D. Frost. Battelle Memorial Institute for Wright Air Development Center. Feb 1956. 50 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. $1.25 (PB 121267)*

Extrusion studies were conducted on two grades of unalloyed titanium to evaluate effects of die design and extrusion reduction. Forward extrusions with reductions of 40, 50 and 60% were accomplished on 3-in. billets with diameters of 1½ in. Working pressures were comparable to those required for cold extrusion of steel. The extruded bars showed uniform deformation and work hardening.

Cordage fiber properties FACTORS AFFECTING THE EFFICIENCY OF CORDAGE. *M. M. Platt, Fabric Research Laboratories, Inc. for Office of Naval Research. Jan 1955. 6 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. 50¢ (PB 121044)*

Summary of research into the mechanical properties of cordage fibers. Factors affecting the translation of strength of fibers in cordage structures and modification of hard fibers through chemical treatment are reviewed. Domestic (Guatemalan and Honduras) Abaca fiber appeared to be equally as useful, on the basis of mechanical properties, as Manila Abaca fiber.

Hard metal grinding ELECTROLYTIC GRINDING OF HARD METALS AND CARBIDES. *I. Weber, Frankford Arsenal, U.S. Army, May 1953. 42 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. $1.25 (PB 111834)*

Electrolytic grinding of hard metals and carbides was investigated as a substitute for diamond grinding. Suitable electrolytes and the various parameters affecting grinding rate were studied.

NEWS OF ENGINEERS COMPANIES SOCIETIES

William C. Dunn, chairman of the board and co-founder of Ohio Crankshaft Co., has received the Trinks Award for "fostering the growth of induction hardening and vastly increasing its scope and usefulness."

Donald L. McClenahan, has been named chief engineer of the newly formed Electrical Testing and Development Laboratory at Schenectady Varnish Co., Inc.

Clement Joseph Savant, Jr., was made chief engineer, Western Div., Servomechanisms, Inc.

W. W. Higgins has been appointed chief engineer of A. O. Smith Corp.

John B. Giacobbe, formerly plant metallurgist for Superior Tube Co., is now director of Superior's newly created Nuclear Products Div.

L. R. Miller was appointed chief engineer of Trent Tube Co.

Dr. George H. Hickox, formerly program director for engineering sciences with National Science Foundation, has been named director of research, Army Corps of Engineers Research and Development Laboratories.

George E. Brumbach has been advanced to chief metallurgist, Carpenter Steel Co.

Dr. William E. Mahin, consulting engineer on research and development problems, has been appointed executive secretary of the Committee on Manpower for the Metallurgy and Ceramics Professions.

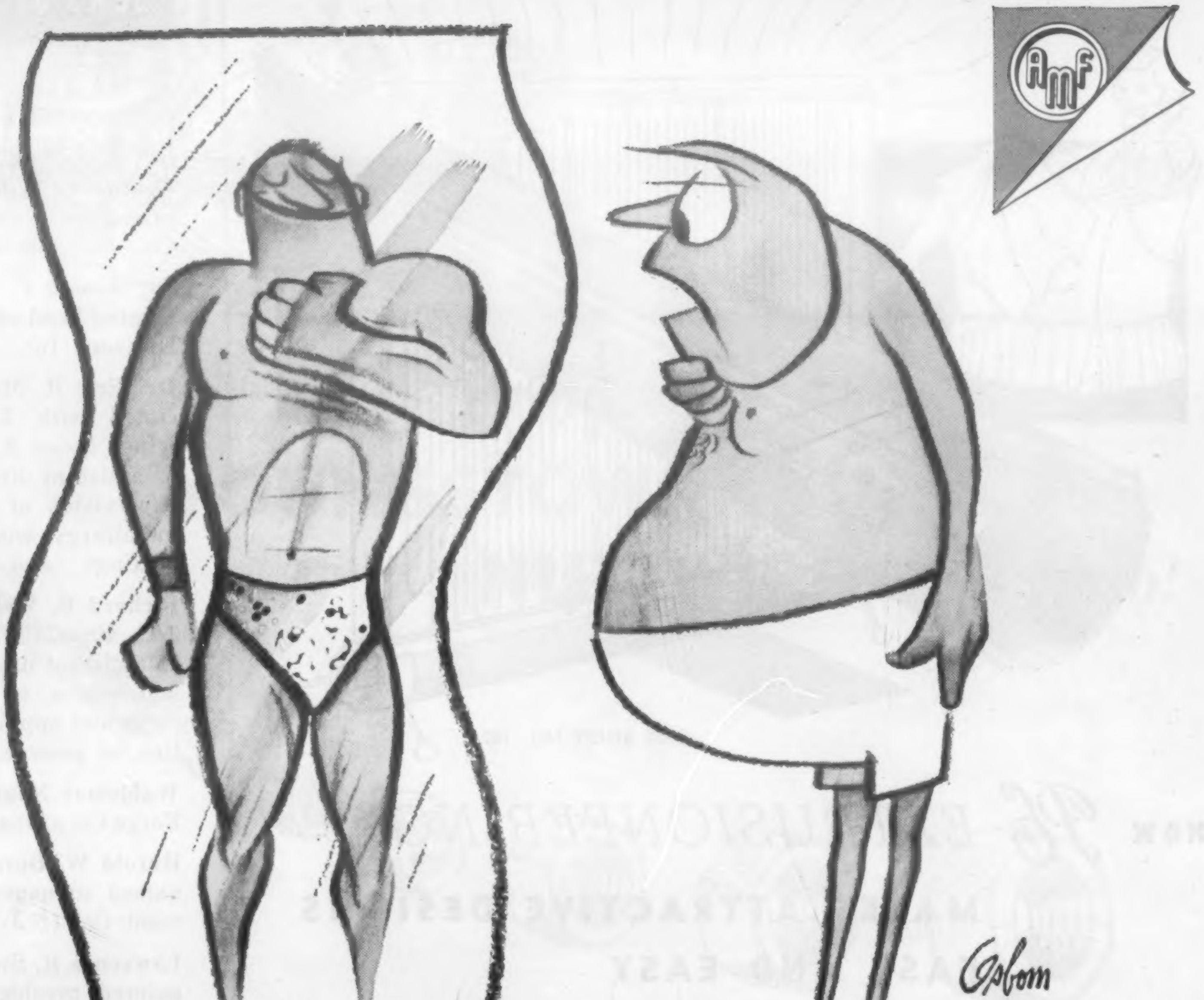
Arthur E. Young is manager of Dow Chemical Co.'s new Textile Fibers Dept.

Joseph A. Brust has been made chief engineer, Efficient Engineering Co., Inc.

Burton R. Buck is a newly appointed vice-president of Electro Metallurgical Co.

Dr. Daniel T. Sigley has been appointed chief engineer for the Guided Missile Div., Firestone Tire & Rubber Co. of Calif. Dr. Sigley replaces **Capt. Frank MacDonald** (USN, retired), who has been named director of the firm's newly established Engineering Laboratory at Monterey, Calif.

Clarence H. Linder, vice president of engineering, General Electric Co., has



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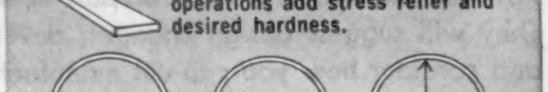

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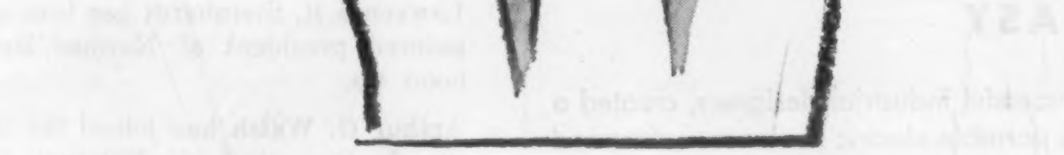

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news of | ENGINEERS

been elected a director of American Institute of Electrical Engineers.

George C. Wilsher is vice president in charge of engineering, Holcroft & Co.

Dr. Ronald C. Vickery has been appointed head of the Chemistry Dept., Horizons Inc.

Dr. Eric R. Morgan, formerly associated with Ford Motor Co., has joined Jones & Laughlin Steel Corp. as assistant director of research with supervision of process and physical metallurgy, analytical chemistry, and coatings and corrosion research.

Richard R. Webster, associated with J&L since 1937, has been promoted to assistant director of research with supervision of instrument development and application of instrumentation to process control.

Waldemar Naujoks has joined Kropp Forge Co. as manager of engineering.

Harold W. Burney has recently been named manager of Metal Improvement Co. (N.J.)

Lawrence R. Steinhardt has been appointed president of Narmco Metlbond Co.

Arthur G. Walsh has joined the Research Div. staff of National Research Corp. He will serve as director of the Process Engineering Dept.

Albert Wiebe, formerly chief engineer of Anchor Mfg. Co., has been appointed industrial specialist with Small Business Administration, New York City.

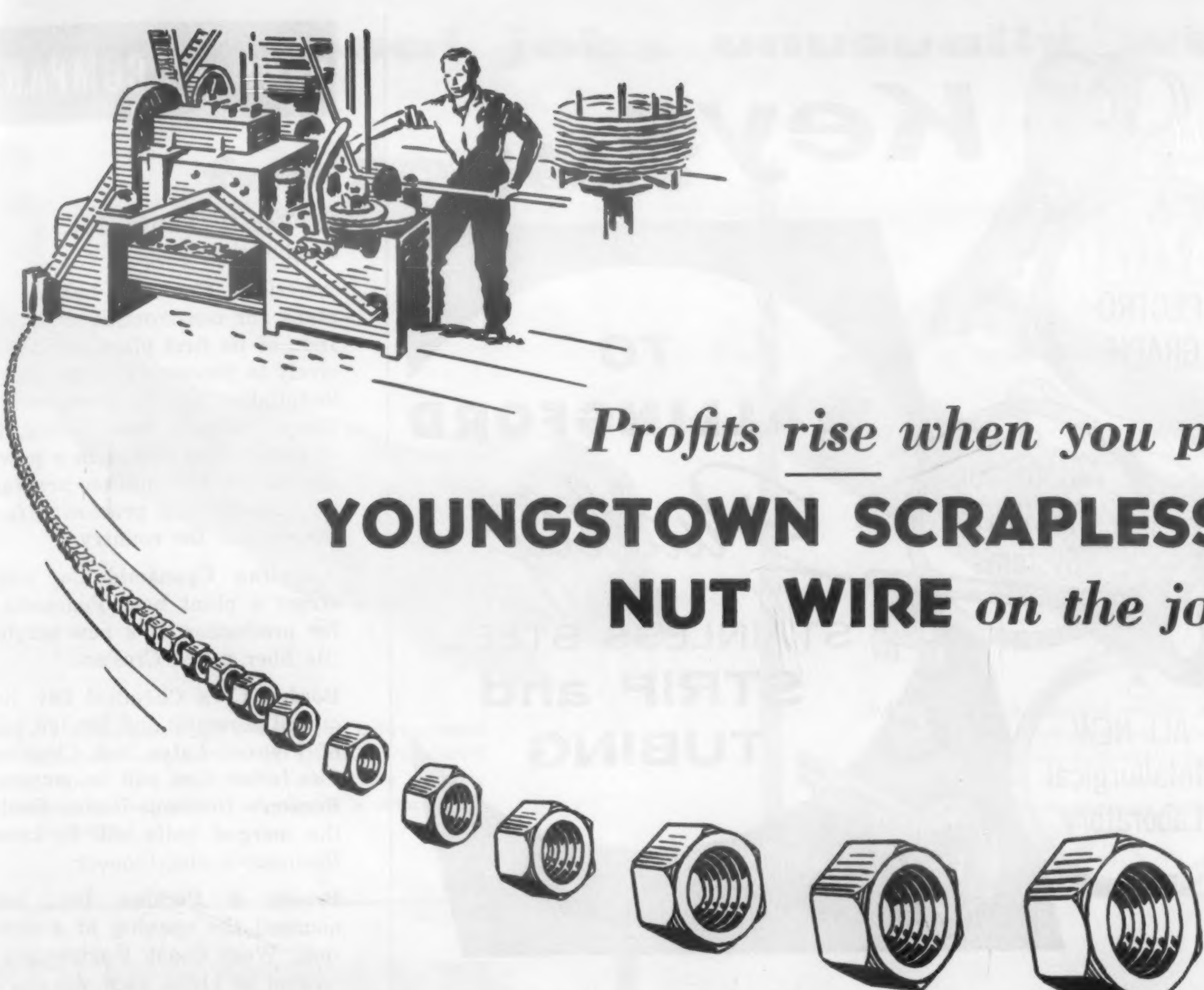
Domenic A. DiTirro is the newly appointed manager of research and development, Valvair Corp.

Robert W. Spacek has been made superintendent of Wellman Bronze and Aluminum Co.'s Peerless Plant.

Henry A. Saller, recently named an assistant technical director at Battelle Memorial Institute, and a specialist in nuclear metallurgy, died suddenly Aug 14.

news of | COMPANIES

Allegheny Ludlum Steel Corp. has contracted to purchase **Paul R. Repath, Inc. Allegheny Ludlum's wholly owned subsidiary, Arnold Engineering Co., will operate this** plant



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For more information, turn to Reader Service Card, Circle No. 426

news of COMPANIES

as Repath Pacific Div. of Arnold Engineering Co.

American Can Co. has announced plans for construction at Hammond, Ind., of its first plant devoted exclusively to processing of tin-plate. This installation, which is expected to be completed late next spring, is one of Canco's first steps in a previously announced $27 million program for large scale plate processing facilities throughout the country.

American Cyanamid Co. will construct a plant near Pensacola, Fla., for production of a new acrylic textile fiber called Creslan.

Borden Co.'s Chemical Div. has acquired domestic and foreign holdings of **Pioneer Latex and Chemical Co.** The latter firm will be merged with Borden's Resinous-Reslac Dept., and the merged units will be known as Resinous-Reslac-Pioneer.

Brooks & Perkins, Inc., has announced the opening of a new division, West Coast Engineering Div., located at 11655 Vanowen St., North Hollywood, Calif.

Cary Chemicals, Inc., has contracted for design and construction of a new PVC resin plant at Flemington, N.J. to be completed next spring.

Corning Glass Works will build a new glass manufacturing plant at Greenville, Ohio. The factory will manufacture Pyrex brand glass products.

Diamond Mfg. Co. has announced the establishment of a new affiliate, **Diamond Perforated Metals Co.,** at 17915 S. Figueroa St., Gardena, Calif.

Doram Products, Inc., has moved both factory and offices to a larger location at 906 Lincoln Blvd., Middlesex, N.J.

Emet Vacuum Forming Corp. has simultaneously announced a change in its corporate name to **Emet Plastics Corp.** and the acquisition of new premises at E. 168th St. and Park Ave., Bronx, N. Y.

General Electric's Medium Induction Motor Dept. has revealed a $2 million expansion in Schenectady, N.Y., for the manufacturing and testing of "canned motor" and electromagnetic pumps for the atomic industry.

Horizons Inc. has been engaged by **Kennecott Copper Co.** as consultants in the design, erection and operation

news of COMPANIES

of a pilot plant to produce zirconium in the Cleveland suburb of Bedford.

Imperial Chemical Industries Ltd., and **Hercules Powder Co.,** in a joint Anglo-American project, will build a $11 million Perspex plant in Louisiana, Mo.

Kaiser Aluminum & Chemical Corp. now has underway a $5½ million program to expand its Newark, Ohio, rod, bar, wire and electrical conductor works.

Michigan Chrome and Chemical Co. has acquired the assets of **Pyramid Plastics Co.**

Minnesota Mining & Mfg. Co. has purchased **Zenith Plastics Co.,** the latter to operate as a wholly owned 3M subsidiary.

Minnesota Rainbow Rubber Co., a new firm producing custom molded rubber parts from colored materials, began operations in Minneapolis recently as the third wholly owned subsidiary of Minnesota Rubber & Gasket Co.

Vapor Heating Corp. has purchased **Roth Rubber Co.**

news of SOCIETIES

American Foundrymen's Society has announced the appointment of S. C. Massari as technical director, and Jack H. Schaum as editor of its publication, *Modern Castings.*

Investment Casting Institute has reported the addition of the following members: **Defense Operations Div. of Chrysler Corp., Corning Glass Co., and Accessories Div. of Thompson Products, Inc.**

Society of Plastics Engineers has appointed James R. Davidson as executive secretary to succeed P. James Underwood, who resigned recently.

Drop Forging Assn. has announced the election of its officers for the coming year. Charles H. Smith, Jr., president, Steel Improvement & Forge Co., was elected president; Gordon R. Walker, president, Walker Forge, Inc., was elected vice president; and Richard Marcus, Association staff member, was elected secretary-treasurer.

For more information, turn to Reader Service Card, Circle No. 415

Meetings and Expositions

FEDERATION OF PAINT AND VARNISH PRODUCTION CLUBS, annual meeting. Cincinnati. Oct 22-24.

METALS CASTING CONFERENCE. Lafayette, Ind. Oct 25-26.

ELECTROCHEMICAL SOCIETY, fall meeting. Cleveland. Oct 28-Nov 1.

GRAY IRON FOUNDERS' SOCIETY, annual meeting. Hot Springs, Va. Oct 31-Nov 2.

SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS, annual meeting and exhibit. Columbus, Ohio. Oct 31-Nov 2.

SOCIETY OF AUTOMOTIVE ENGINEERS, diesel engine meeting. Chicago. Nov 1-2.

PORCELAIN ENAMEL INSTITUTE, annual shop practice forum. Urbana, Ill. Nov 7-9.

STEEL FOUNDERS' SOCIETY OF AMERICA, technical and operating conference. Cleveland. Nov 7-9.

NATIONAL ASSN. OF CORROSION ENGINEERS. Southeast Region, Charlotte, N. C., Nov 8-9. Western Region, Long Beach, Calif., Nov 15-16. North Central Region, Detroit, Nov 15-16.

INVESTMENT CASTING INSTITUTE, annual meeting. Detroit Nov 13-15.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, annual meeting. New York. Nov 25-30.

AMERICAN ROCKET SOCIETY, annual meeting. New York. Nov 26-29.

NATIONAL CHEMICAL EXPOSITION. Cleveland. Nov 27-30.

SOCIETY OF THE PLASTICS INDUSTRY, Film, Sheeting and Coated Fabrics Div. conference. New York. Dec 4-5.

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS, electric furnace steel conference. Chicago. Dec 5-7.

SOCIETY OF AUTOMOTIVE ENGINEERS, annual meeting and engineering display. Detroit. Jan 14-18.

SOCIETY OF PLASTICS ENGINEERS, annual national technical conference. St. Louis. Jan 16-18.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, winter general meeting. New York. Jan 21-25.

AMERICAN SOCIETY FOR TESTING MATERIALS, committee week. Philadelphia. Feb 4-8.

GRAY IRON FOUNDERS' SOCIETY, committee week and spring meeting. Philadelphia. Feb 4-8.

MATERIALS ENGINEERING NEWS

continued from p 13

Company Partnership Ups Aluminum Supply

An increased supply of primary aluminum will result from the recent formation of Olin Revere Metals Corp. Originally, Olin Mathieson planned to produce 60,000 tons a year and to build a reduction plant on the Ohio River. Now, since the agreement with Revere Copper and Brass to form the new corporation, the expected rate is 180,000 tons, and a 350,000-ton-capacity alumina plant on the Gulf Coast has been added to the proposed plans.

The new concern satisfies Revere's long felt need for its own source of primary aluminum. Of the 180,000 tons, one-third is contracted for by Revere. Part of this supply will be fed to sheet, tube and extruded shapes departments in Baltimore; the remainder will go to a new sheet plant in Chicago.

Olin Mathieson will obtain 120,000 tons—double the supply anticipated last January—at a lower cost per ton. Half this supply will be fabricated in a rolling mill to be built near Clarington, Ohio; the remainder in Midwest and West Coast plants.

(more News on p 238)

Lunn Laminates, Inc.

Large oven is needed to cure this radome molded of reinforced plastics.

See what adhesives are doing today!

THIS 3M SEALER PERFORMS SO DEPENDABLY, DOUGLAS AIRCRAFT FINISHES CABINS ENTIRELY BEFORE PRESSURE TESTING.

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MATERIALS ENGINEERING NEWS

Recent Highlights of ASTM Activity

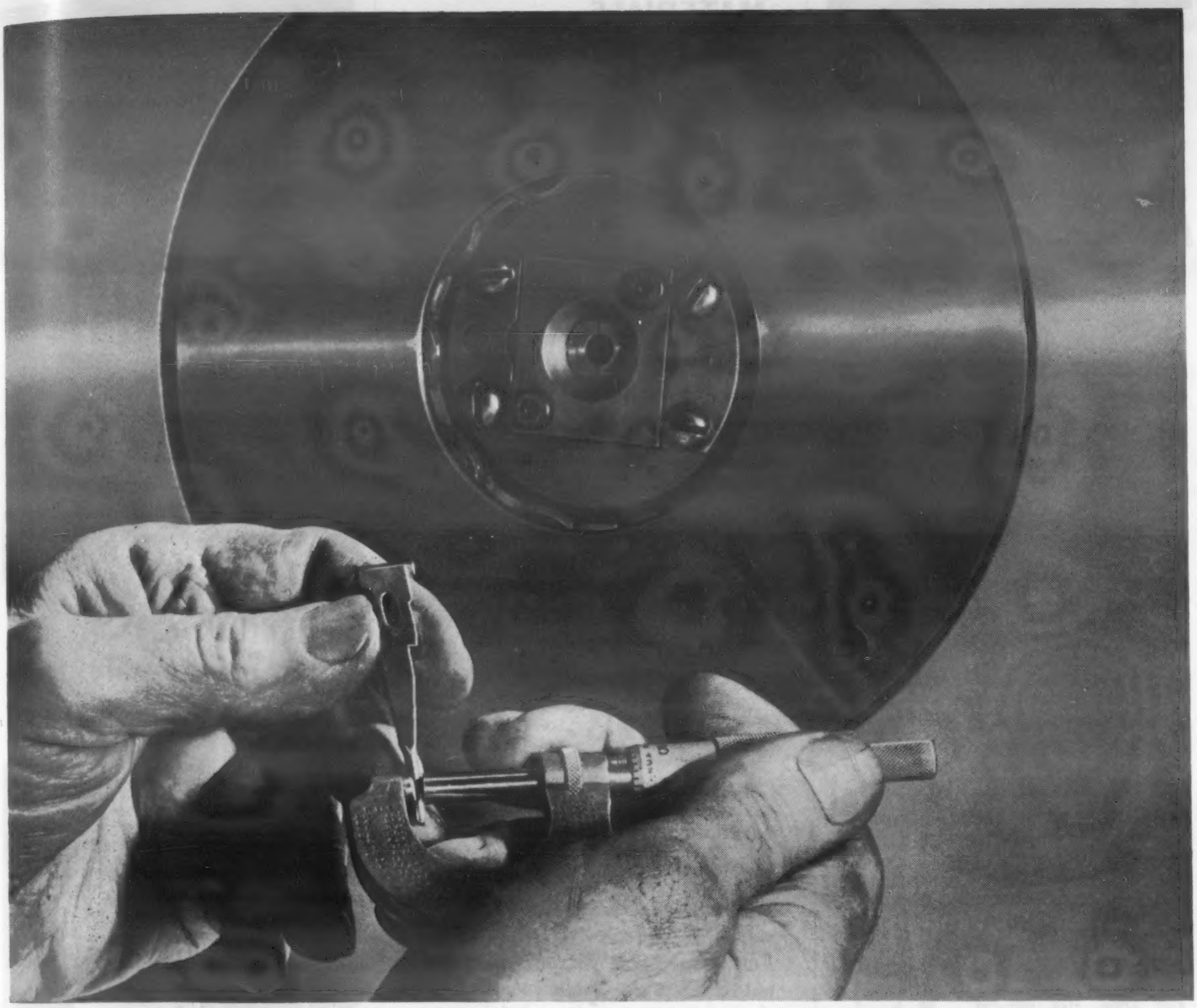
Appearance may exert as much influence over the choice of an engineering material as its physical properties. For this reason, Committee E-12 of the American Society for Testing Materials is now considering the preparation of a manual on Appearance Properties of Materials. Such a manual might include detailed information on dimensions of appearance, instruments of appearance, evaluation, instruments of operation, appearance measurement practices in different industries, and terms and definitions.

The growing interest in control of appearance was only one of numerous projects and research papers considered at the ASTM's annual meeting several months ago. Some of the other high points are discussed below.

Metals

Brittle skins—The paper, "The Effect of Brittle Skins on the Ductility of Metals," by G. W. Form, Ecole Polytechnique Montreal, and W. M. Baldwin, Jr., Case Institute of Technology, was of particular interest. The literature contains many references to this problem, all of which suggest that a brittle skin is capable of embrittling a metal out of all proportion to the percentage of the bulk that the skin itself occupies. R. E. Richsecker and T. S. Howald of Chase Brass and Copper Co. said quantitative evaluation of the effect of hydrogen embrittlement and the profound effect of plated skins on ductility of the base metal is very important in making parts from copper and copper alloys.

Wire fatigue—A wire fatigue machine for investigation of the influence of complex stress histories was described by H. T. Corten and G. M. Sinclair, of the University of Illinois. The machine operates on the principle of a deflected rotating strut. Major



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MATERIALS ENGINEERING NEWS

difference between this and previous wire machines is that the stress may be changed rapidly from one level to another without inducing extraneous vibration in the specimen.

Magnetic inspection—Of particular interest to users of iron and steel castings is the development of a set of reference photographs of magnetic particle indications on ferrous castings. A task group consisting of representatives of Subcommittee III of American Standards Assn. Sectional Committee B 31, the Manufacturers' Standardization Society of the Valve and Fittings Industry, the Steel Founders' Society and ASTM presented a set of these photographs to Committee E-7.

The photographs depict varying degrees of severity of linear discontinuities (cracks and hot tears), shrinkage, inclusions, internal chills and unfused chaplets, porosity, and weld defects. They were collected by the Steel Founders' Society from its member companies. Also included in the set are examples of false indications and magnetic anomalies.

The reference photographs are intended for use when specified in contracts, orders, material specifications or codes, and when the limiting class of severity is mutually agreed upon by the manufacturer and the purchaser. Publication date has tentatively been set for this fall if the committee ballot is favorable. Committee A-3 on Cast Iron has petitioned Committee E-7 to prepare reference radiographs of the discontinuities peculiar to nodular iron and cast iron in general.

Soldering — Two papers suggested new approaches to specific standardization practices in soldering. L. Pessel of the Radio Corp. of America proposed a numerical evaluation system for soft solders, fluxes and solderability. This system showed significant correlation with practical

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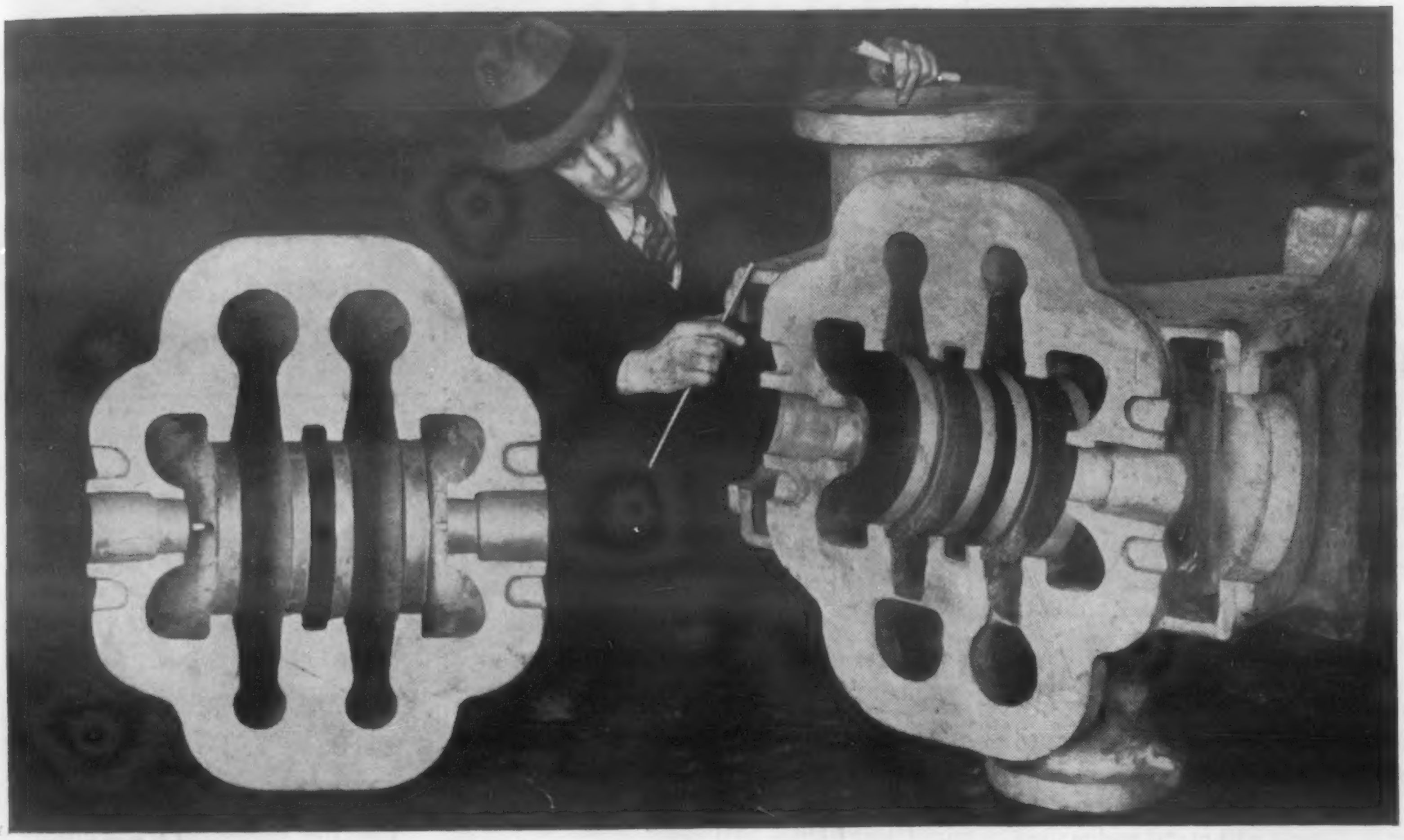
performance and may prove generally useful in advancing soldering technology. The second was a proposed Method for Testing and Evaluating the Joint Properties of a Copper Liner Soldered in an Aluminum Casting presented by M. V. Davis, of Anderson Electric Corp. This method measures the strength of the solder bond between the copper liner and the aluminum casting used in bimetallic electrical conductor connections. It provides an empirical quantitative measurement of the joint strength of the solder bond.

Structural steel—A new high strength, alloy structural rivet steel specification is being developed. This steel composition is intended for applications where rivet steel furnished to Specification A 195 has proved unsatisfactory. Also, a new high strength structural steel is being studied, for which considerable data on static and fatigue strengths will

Bart Mfg. Corp.

Nickel plate is applied to the interior surface of seamless steel pipe by using the rotating pipes as their own plating tanks. A nickel solution swirls around the inside, electrolytically depositing a smooth, pore-free, ductile lining of pure nickel.



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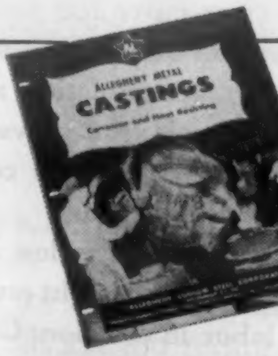

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MATERIALS ENGINEERING NEWS

soon be available.

Pressure vessels—Three new pressure vessel specifications will be prepared paralleling the present A 201, A 212 and A 285 specifications but containing an additional provision for low residual copper content. It was also recommended that A 201, A 212 and A 204 contain an additional requirement to prohibit graphitization at high temperature service. This clause states that when the steel is used at 800 F or above the steel is to have added to it a maximum of ¾ lb of aluminum per net ton and should have a McQuaid-Ehn grain size of 1 to 4. Both of these developments are the result of requests from the petroleum industry for plate materials deemed necessary in the construction of processing equipment.

Ultrasonic testing—A proposed recommended practice for ultrasonic testing and inspection of turbine and generator steel rotor forgings is in final form and may be published late this year.

Tube and pipe—Two new tube and pipe specifications are underway. A new specification will be written to supplant Case 1208 of the ASME Boiler and Pressure Vessel Code and will cover special corrosion resisting alloy steels for economizer tubes in high pressure boilers. In addition, since sufficient data now appear to be available, a draft specification for centrifugally cast ferritic alloy steel pipe for high temperature service will be prepared.

Finishes

Surface preparation—Preparation of metal surfaces for painting has been under study by Committee D-1 for several years. Variations in surface treatment produce end conditions which differ and which do not necessarily yield identical results when paints are applied. Service conditions dictate the type of surface preparation that should be selected, although the quality produced by any individual method may vary

MATERIALS ENGINEERING NEWS

with different alloys. Two methods were completed by Committee D-1 this year: one for preparation of aluminum and aluminum alloy surfaces and the other for magnesium alloy surfaces. The former covers solvent cleaning, chemical anodic and mechanical treatments. The procedure for preparation of magnesium surfaces includes chemical and anodic treatments. The methods of preparation are intended primarily for test panels, although some of these same treatments are being used commercially.

Thickness measurement — Another new method covers procedures for measurement of film thickness by means of an inductance gage and a penetration gage. These methods provide for nondestructive measurements of electrically nonconductive dry films of paint, varnish, lacquer and related products when applied over a nonmagnetic metal base.

Rubber and plastics

Synthetic elastomers—Committee D-11 completed five new tentatives covering synthetic elastomers and rubber latices. Work on these materials was undertaken by the Committee following the Government's decision to sell its synthetic rubber facilities to private industry. This transfer made it necessary for the purchasers of the Government plants and those concerned with the commercial use of their production to assume responsibility for future standardization activities. Committee D-11 offered its services and a new Subcommittee XIII on Synthetic Elastomers was established. The five new tentatives cover: 1) Nomenclature for Synthetic Elastomers and Latices, 2) Description of Types of Styrene Rubbers (SR), 3) Description of Types of Styrene Rubber (SR) and Butadiene Rubber (BR) Latices, 4) Chemical Analysis of Synthetic Elastomers (Solid Butadiene-Styrene Copolymers), 5) Sampling and Physical Tests for Synthetic

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MATERIALS ENGINEERING NEWS

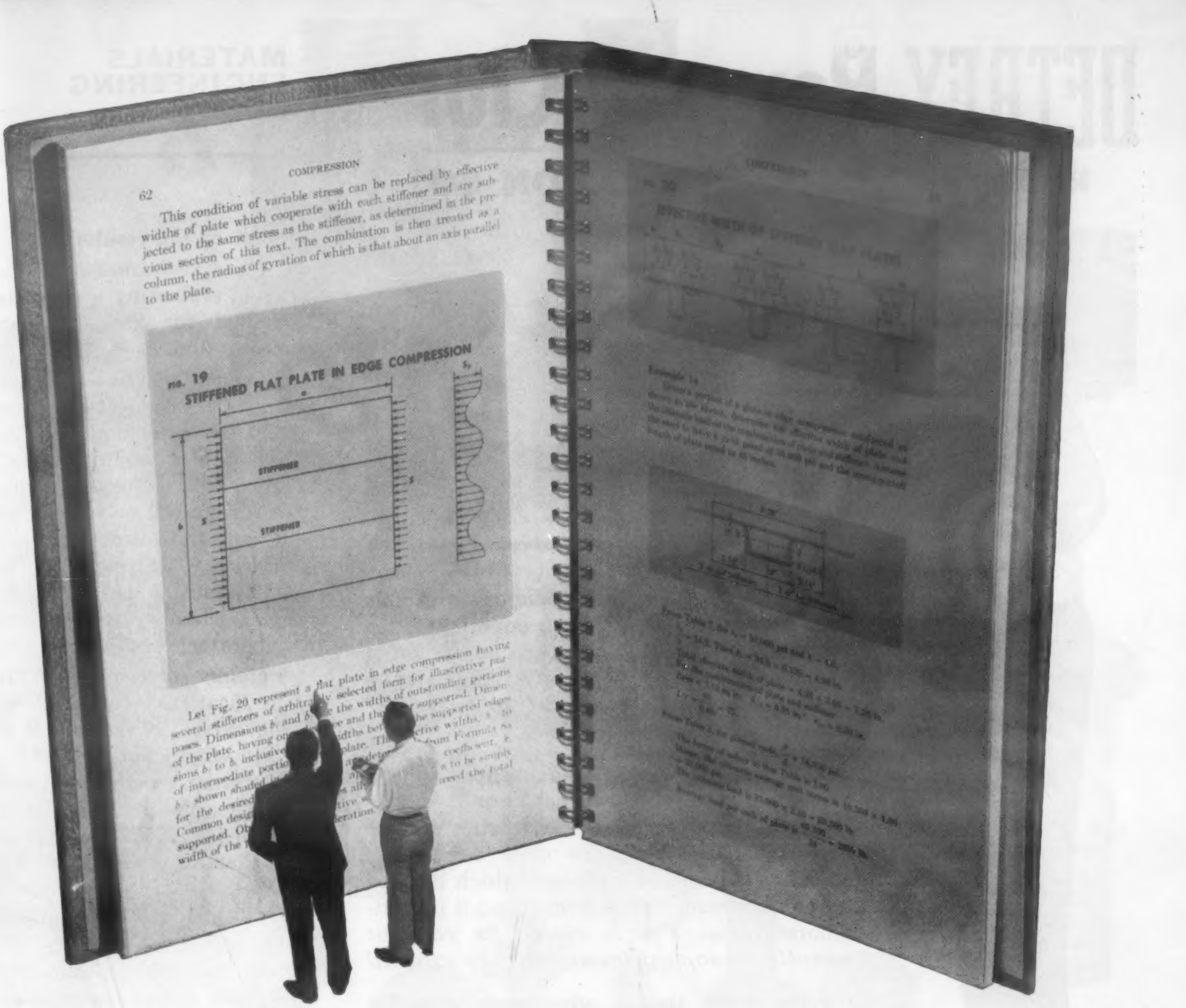
Rubber Latices (Butadiene-Styrene Copolymers).

Irradiation—A new section on the effects of nuclear and high energy radiation on plastics was organized. This section is part of Committee D-20's Subcommittee V on Permanence. Chairman of the new radiation group is D. S. Ballantine, of Brookhaven National Laboratories. Committee D-9 on Electrical Insulating Materials has accepted an invitation to participate in the radiation studies and has requested that it be a joint activity of the two committees.

Polyethylene stress-cracking—Stress-cracking is a characteristic of polyethylene which has been found rather difficult to evaluate, and the Committee intends to submit for publication as information a draft describing the best currently available procedure for determining stress-cracking together with a discussion of the limitations of the method and signifi-

General Electric Co.

Five-stand tandem cold strip mill at Weirton Steel Co. delivers steel strip at the record rate of 80 mph. It is powered by motors totaling 28,000 hp.



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cance of the results.

Snag resistance—The Committee is evaluating a suggested test method for snag resistance of plastic film.

Cellular plastics—Cellular Plastics is the subject of a newly organized subcommittee. Sections were authorized covering cellulosic, epoxy, isocyanate, phenolic, urea, vinyl, polyester, silicone, styrene and polyethylene expanded plastics. Chairman of the new subcommittee is I. J. Stoneback of Federal Telecommunication Laboratories.

Molding compounds—Three new specifications covering molding and extrusion compounds of nonrigid vinyl chloride plastics, polychlorotrifluoroethylene and styrene-acrylonitrile copolymer prepared by ASTM Committee D-20 on Plastics were approved as tentative.

The new spec for nonrigid vinyl chloride plastics is the result of revisions and consolidation into one spec of two tentative specs on nonrigid vinyl chloride-acetate resin plastics (D 742-46T) and nonrigid polyvinyl chloride plastics (D 744-49T). The new tentative specification covers currently available grades of commercial materials such as those used for garden hose, raincoats, shower curtains and the like.

The new spec for polychlorotrifluoroethylene covers four commercial grades of this material and includes three new methods of test specifically for identification of these grades. The styrene-acrylonitrile copolymer spec covers one general purpose type of this material. Others will be added in the future as the need arises. The copolymer is available commercially under a variety of trade names.

Electrical contacts

For several years efforts to develop a reproducible test for surety of make of electrical contacts have been unsuccessful because of difficult - to - control and elusive

variables. Interlaboratory tests using standardized procedures have not yielded results meeting statistical expectations. According to a report by P. N. Bossert, of Union Switch and Signal Co., to the Electrical Contacts Subcommittee of Committee B-4 on Electrical Heating, Electrical Resistance and Electrical Contacts, identification and control of these variables may be in the offing.

Extremely thin films of corrosion products or other contamination on the contact surfaces presumably are the source of difficulty, since they impair direct metal-to-metal contact. Dr. Bossert conceived a method for measuring the a-c component of thermal resistive noise across a d-c contact, associating high values of noise with films. Using a sensitive oscilloscope, he was able to show that, despite careful vibration isolation of the contact assembly, noise components were generated by talking nearby or by a moderate hand-clapping 3 ft away.

Silver contacts at 3 gm force were practically free from "sound" effect, but the effect appeared with tungsten and copper at contact forces as high as 30 gm. These findings seem to indicate that a more reproducible test could be devised by restricting testing conditions to avoid the sound effect phenomenon.

Other reports on contact investigation indicated that contacts are sensitive to vibration, impact and electromagnetic radiation, and these factors must also be taken into account in devising a standard test.

Chemical Milling Used on Large Parts

Wing skin panels, some of which measure as much as 20 ft long by 6½ ft wide, are being chemically milled by the U. S. Chemical Milling Corp. In this work, 0.125-

TECHNICIANS LESTER FILLER (front) and **EVERETT FLOM** prepare to radiograph the internal structure of a vertical stabilizer on a Beech T34A. They're using Triplett & Barton's new 65-lb. portable x-ray unit with Du Pont Type 506 Fine Grain Industrial X-ray Film.

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ROBERT E. NASE, Du Pont Technical Representative is a frequent visitor at the Triplett & Barton Lab. Here, at the illuminator, he discusses the interpretation of the radiograph taken above.

Hank Wyckoff, manager of the Triplett & Barton X-ray Laboratory at Beech Aircraft, goes on to say: "We've used Du Pont X-ray Film in all our branches for the past 15 years. During this time we have made over twenty million exposures, We have done more research work with Du Pont's Type 506 than any other industrial x-ray laboratory in the country and we recommend it to our customers on the basis of this research."

You can depend upon Du Pont Industrial X-ray Film to register even the most minute flaw in a part—this dependability results in tremendous savings in man hours, machine time and inspection time. First of all, its good contrast, stability and uniformity simplify interpretation. The blue base cuts eyestrain and the wide latitude helps solve your difficult exposure problems. The packaging without interleaving paper of Du Pont 506 N.I.F.* eliminates darkroom clutter and speeds handling. Holder loading is faster, too. And you always have the services of a Du Pont Technical Representative on any x-ray problem you may encounter.

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MATERIALS ENGINEERING NEWS

in. material is being reduced to a thickness of 0.015 in. and held to a tolerance of ± 0.003 in. throughout the area of the panels. Although these are the largest parts ever chemically milled, the plant has facilities to handle parts up to 50 ft in length and 12 ft in width.

SPE Symposium on Isocyanates

A symposium on isocyanate-base polymers—a relatively new class of chemicals that are becoming of increasing commercial interest in protective coatings, foams, adhesives, potting compounds and rubber polymers—has been scheduled. It will be held Oct 23 at the Curtis Hotel, Minneapolis, Minn. The Society of Plastics Engineers, Inc., Upper Midwest Sec, is presenting the meeting.

Raybestos-Manhattan, Inc.

Brake lining material contains brass alloy chips to improve heat transfer and thus prevent overheating. The flexible molded material is specifically designed for use on both internal and external drums, eliminating the need for two types of brake lining.

For more information, turn to Reader Service Card, Circle No. 428

LETTERS TO THE EDITOR

continued from p 14

Forming small tubing

To the Editor:

I have read, with a great deal of interest, the excellent staff report on "Fabricated Metal Parts—Design and Selection Factors" in the February 1956 issue of MATERIALS & METHODS. I found Section 19, "Sectioned Tubing," of particular interest.

In reading your magazine I have not noted any advertisements on the forming of small copper or brass tubes. If, however, you have any information as to the names of several companies that are equipped to form tubing, I would appreciate any assistance you may be able to give me.

A. B. LEVERING, Engineer
General Electric Co.
Pittsfield, Mass.

A list of companies has been sent.

Ultrasonic fusion

To the Editor:

I see on page 3 of the July 1956 issue of MATERIALS & METHODS a notation on ultrasonics for welding metals.

Such a method could be extremely useful in the fusion of plastic materials . . . Can you give me a further source of information regarding the use of ultrasonics for such fusion?

I see on page 4 a mention of seamless hollow shapes produced by a unique method, eliminating cementing or welding of seams. This apparently is a thermochemical splitting of a single sheet. Will you be so kind as to give me a reference so that I may learn more of this process.

WM. P. MURPHY, JR., Director of Research and Development
Dade Reagents, Inc.
Miami, Florida

Heatless welding of metals by ultrasonics was reported to the American Welding Society by J. B. Jones of Aeroprojects, Inc., West Chester, Pa., and J. J. Powers, Jr., of Pitman Dunn Laboratories, Frankfort Arsenal, Philadelphia. We would suggest contacting them regarding the feasibility of using the process on plastics. The method for producing seamless hollow shapes was reported by the Walter Opavsky Laboratory in Coburg 3, Germany. It goes under the trade name of the Holofol Process and is discussed further in this issue, p 114.

Nuclear materials

To the Editor:

I would be grateful if I could receive a copy of your MATERIALS & METHODS Manual No. 129, "Materials for Nuclear Power Reactors." This paper seems to cover the subject most comprehensively.

JULIUS J. HARWOOD, Head
Metallurgy Branch
Office of Naval Research
Washington, D. C.